RESEARCH CIRCULAR 253 JANUARY 1980

Ornamental Plants - - 1980: A Summary of Research

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER
U. S. 250 and Ohio 83 South
Wooster, Ohio

CONTENTS

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ON THE COVER: Dr. Steven M. Still is shown checking the roots on a summer rooted cutting. Dr. Still joined the Dept. of Horticulture in July 1979 and is focusing his research on the propagation and production of woody plant materials on their own roots rather than by grafting or budding.

AGDEX 272-275-276/16-24-28

1-80-2.5M

Computer Analysis of Production Costs for Containerized Nursery Products

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ABSTRACT

An interactive computer program was developed to determine containerized nursery production costs. The user reads in direct and indirect expenses, production square footage, estimated shrinkage, desired rate of return on investment, and total equity investment. Nurserymen can determine costs for a specific plant species with variable container size, overwintering method, and production time. The program prints individual costs of production compared to average industry costs obtained in a recent survey of Ohio nursery businesses. Average industry costs can be updated annually to reflect the most current production cost information. A portable computer terminal can be used to access the program by telephone from anywhere in the United States. Results can aid nurserymen in decisions concerning product mix, production levels, pricing, and promotion.

INTRODUCTION

Containerized nursery production has increased throughout the U. S. during the past two decades. Initially, many producers supplemented their field operations with containerized production. Currently, ornamental plants sold in containers account for 14% of total sales (5, 6). Previous studies indicate that labor is the largest single expense, accounting for approximately 40% of total costs (1, 2, 3). However, little detailed information is available on the costs of producing plants in a containerized nursery.

The objectives of this study were to develop an interactive computer program to aid the nursery industry in establishing detailed production costs on a uniform basis and to establish a data base for average industry production costs for different size producers. Interactive means that the computer will prompt the user for information.

MATERIALS AND METHODS

Industry data for this study were obtained from 10 wholesale nurseries producing containerized stock throughout Ohio during the summer of 1977 (4). The production cycle began with the insertion of a rooted liner into a container and terminated when the plant reached a marketable state. The entire production cycle was segmented into eight separate cost factor divisions. These divisions were: canning program, fertilizer program, weed control program, shifting program, pruning program, spacing program, overwintering program, and overhead. A range of production costs associated with each cost factor division was developed. The values establishing the boundaries of the range represent actual costs for cooperating firms.

The computer program estimates production costs on both a square foot and production unit basis after being adjusted for space utilization, shrinkage, and desired rate of return on investment. Comparative industry data provide benchmark costs which will serve as a guide for the individual nurseryman in evaluating his relative cost competitive position in relation to other nursery businesses of similar size.

The computer program is an interactive program written in the Fortran IV programming language. Program users need not be programming experts or have any computer expertise at all to use the program.

The cost analysis has two sections. First, production costs were analyzed on the basis of a 12-month production cycle for three container sizes: 1, 2, and 3 gallon. Second, an analysis of production costs based on the information obtained from the first section was used to estimate costs associated with the production of different species of plant material having different cultural requirements. In order to assign production costs, cultural groupings were developed for several species which are handled similarly throughout their production cycles. The representative costs were applied to each cultural grouping and the corresponding cost category by the number of months needed to produce a saleable product.

The analysis provides information about production costs on a 12-month basis regardless of cultural grouping. Detailed information concerning production costs of specific plant material based on their cultural requirements is also provided. The species in each cultural grouping are listed in Table 1.

To develop comparative data, production costs from the 10 firms were divided into three size classifications. The classifications are presented in Table 2.

Since the producer is ultimately interested in the profitability of the business, the 12-month production

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cost analysis frequently does not provide adequate information. To evaluate profitability of many different types of plant material comprising the product mix, production costs should be apportioned based on cultural requirements of different species classifications. For example, Group III plant materials (narrowleaf evergreens) require 24 months to reach saleable size in a 1-gallon container, whereas

TABLE 1.—Plant Genus, Species, and Input Code by Cultural Group.

	Code
Group I	
Berberis thunbergi	B T
Chaenomeles japonica	C J
Cotoneaster apiculata	C A
Cotoneaster horizontalis	C H
Euonymus alatus	E A
Ligustrum vulgare	L V
Viburnum (species)	V
Weigela hybrida	W H
Other	O G 1
Group II	
Buxus microphylla koreana	B K
Euonymus fortunei	E F
Mahonia aquifolium	M A
Pyracantha coccinea	P C
Cotoneaster dammeri	C D
Other	O G 2
Group III	
Chameacyparis (species)	C
Pinus (species)	P
Thuja (species)	T
Other	O G 3
Group IV	
Rhododendron (species including Azalea)	R
Pieris japonica	P J
Other	O G 4

Production Cycles by Cultural Requirements

Cultural Group	Time Required No. 1 Containers	Time Required No. 2 Containers	Time Required No. 3 Containers
	months		
Group I	12	24	24
Group II	12	24	24
Group III	24	24	36
Group IV	12	24	24

TABLE 2.—Producer Classification by Size.

Producer Size Classification	Production Area*
	(square feet)
Small	Less than 100,000
Medium	100,000 - 400,000
Large	More than 400,000

*Production area is defined as that area enclosed within the hoop houses.

only 12 months are required for Groups I, II, and IV (Table 1).

In order to assign costs to the various groups based on cultural requirements, the following assumptions were made: 1) all plant materials saleable in 1-gallon or 2-gallon containers were canned and produced in their corresponding saleable container size, and 2) all plants saleable in 3-gallon containers were shifted once from 1-gallon containers. Production times required in the nursery by cultural groups to obtain saleable size are listed in Table 1.

Figure 1 is a flowchart representation of the computer program. The program contains several sections which can be characterized as major input and/or output sections. Each section, as denoted by numbered brackets, will be discussed.

After completing the coded procedure for accessing the program, section 1 (Fig. 1) establishes preliminary information about the program user's business and the total cost of several overhead expense items for each production year. The first series of inputs is as follows:

```
READ IN THE NUMBER OF YEARS FOR WHICH
YOU WILL ENTER DATA. A MAXIMUM OF
THREE YEARS MAY BE SPECIFIED.
?

THE FOLLOWING SECTIONS WILL ASK FOR DATA
BY YEAR.
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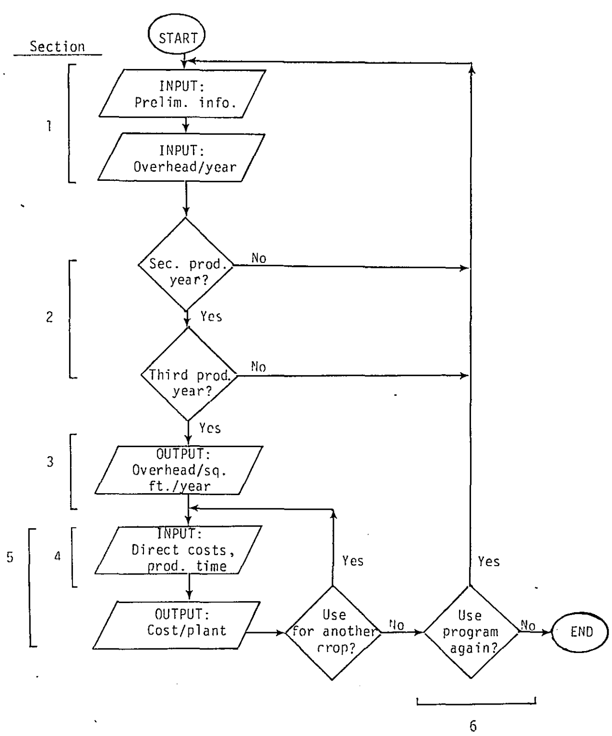

FIG. 1.—Flowchart representation of containerized nursery product production cost computer program.

READ IN DATA FOR THE FIRST PRODUCTION YEAR.
READ IN YEAR
?
READ IN SQUARE FEET IN PRODUCTION
?
READ IN PERCENT SPACE UTILIZATION
?

The number of years for which data will be entered should be the number of calendar years of production time to a maximum of 3 years. The subsequent inputs establish general information for each year.

Total cost for each of the following overhead costs for each production year is also input in section 1 of the program (Fig. 1). Requested overhead costs are as follows:

READ IN COST OF INSURANCE
?
READ IN COST OF MACHINERY REPAIRS
?
READ IN COST OF BUILDING REPAIRS
?
READ IN COST OF UTILITIES
?
READ IN COST OF TAXES
?
READ IN COST OF OFFICE SALARIES
?
READ IN COST OF ADMINISTRATIVE AND OFFICE SUPPLIES
?
READ IN COST OF BUILDING AND GREENHOUSE DEPRECIATION
?
READ IN COST OF EQUIPMENT AND MACHINERY DEPRECIATION
?
READ IN TOTAL EQUITY INVESTMENT
?
READ IN DESIRED RATE OF RETURN ON INVESTMENT
?

Overhead cost is calculated on a space adjusted per square foot basis. Overhead costs are adjusted to reflect 100% space utilization in the production area. For example, if 90% production area space utilization is input by the program user, the output overhead cost/ft^2 will be increased by 10% to reflect full space cost allocation to the area actually in production. Table 3 presents a summary of program inputs to calculate overhead cost/ft^2/year.

If more than 1 year of data was specified in the preliminary information section, the program will request overhead costs for the additional year or years in section 2 (Fig. 1). Rather than having to re-enter all the overhead costs, the program will ask if the second year's overhead costs are the same as the first year's. If the costs are the same, no further overhead input is necessary because the program re-uses the first year's costs in calculating the second year's overhead cost/ft^2. If costs are not the same, the program recycles to the preliminary information section (section 1, Fig. 1) and new data are supplied for the second production year. A similar procedure is followed if a 3-year production time has been specified. Figure 2 presents sections 1 and 2 (Fig. 1) of the flowchart showing the cycling process for second and third year overhead cost data.

After overhead costs have been read in for each year, the overhead cost/ft^2/production year output is made in section 3 (Fig. 1) of the program. Table

TABLE 3.—Summary of Program Inputs to Calculate Adjusted Overhead Cost/Ft^2/Year.

Read in Year
Read in Square Feet in Production
Read in Percent Space Utilization
Read in Cost of Insurance
Read in Cost of Machinery Repairs
Read in Cost of Building Repairs
Read in Cost of Utilities
Read in Cost of Taxes
Read in Cost of Office Salaries
Read in Cost of Administrative and Office Supplies
Read in Cost of Building and Greenhouse Depreciation
Read in Cost of Equipment and Machinery Depreciation
Read in Total Equity Investment
Read in Desired Rate of Return on Investment

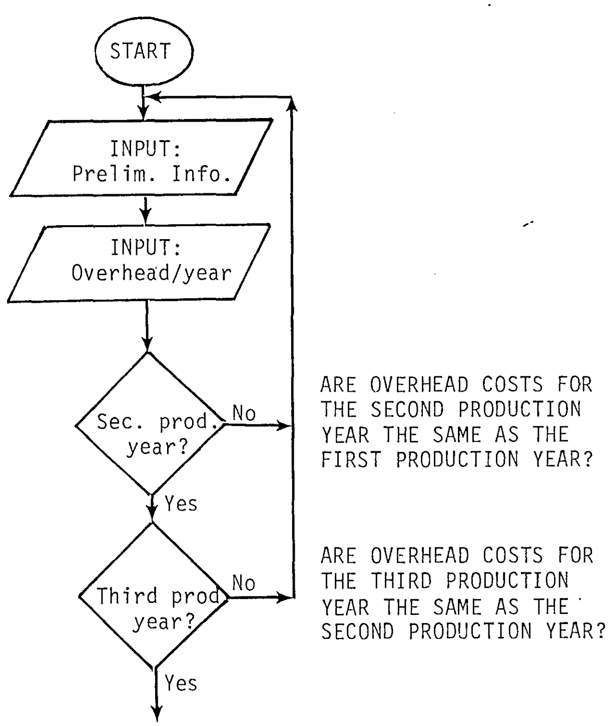

FIG. 2.—Overhead cost data entry options for second and third production years.

TABLE 4.—Sample User's Overhead Cost/Ft² and Comparison to Industry Average.

	Production Cost Dollars	Industry Av. Dollars
Overhead Costs per Square Foot for 1978		
Cost of Insurance	0.015	0.013
Cost of Machinery Repairs	0.010	0.003
Cost of Building Repairs	0.004	0.003
Cost of Utilities	0.042	0.042
Cost of Taxes	0.002	0.002
Cost of Office Salaries	0.102	
Cost of Administrative and Office Supplies	0.002	
Cost of Administration and Management	0.286	0.480
Cost of Building and Greenhouse Depreciation	0.041	0.006
Cost of Equipment and Machinery Depreciation	0.071	0.096
Return on Investment	0.158	0.047
Total Overhead Cost per Square Foot 1978	0.734	0.693
Total Adjusted Overhead Cost per Square Foot 1978	0.798	0.770

4 presents a sample overhead cost/ft² output table for one production year. Overhead costs for each year are itemized as they were input, but now on a per ft² basis (Table 4). The first column of the output table, Production Cost, is the program user's cost/ft² and the second column, Industry Average, is the industry average for the same size of producer as the user (Table 2).

Total overhead cost/ft² is calculated including return on investment and then adjusted to reflect 100% space utilization. If overhead costs are the same for all production years, only one table representing all years will be printed. If overhead costs are different, a table for each production year will be printed. Industry average space utilization has been fixed at 90%, so industry average overhead cost is increased by 10%.

After printing the overhead cost table, the program requests direct costs for a specific crop in section 4 (Fig. 1). The first input, Print Initials of Genus and Species, establishes the cultural group for the specific plant. In the cost survey that this program is based on (4), crops were grouped according to similar handling practices (Table 1). Average direct costs were then assigned to these groups.

For use in this program, each genus and species within each group has been coded to facilitate input. The first letters of the genus and species are used for coding. Plants not specifically named, but handled in a manner similar to one of the groups, can be input by using the "Other" category for each group. Reading the plant code cues the program as to which costs should be output as industry average costs for the selected cultural group.

Table 5 present direct costs that must be read in for each crop. The container information section establishes the container size, type, labor, and growing media that the program user is utilizing, so that the appropriate industry average canning cost is printed. The user input cost of canning should include all costs associated with the container. Similarly, reading the code for the user's overwintering method cues the program as to which overwintering cost should be printed as the industry average based on the overwintering method and producer size classification. In a later section of the direct inputs, the user supplies the specific overwintering cost. The user also supplies the production time (months), space required (in²), and percent shrinkage in each production year (Table 5).

After supplying all direct inputs, the product's total unit cost is calculated and printed in section 5 of the program (Figure 1). Table 6 presents a sample unit cost output table. Liner cost and canning cost are printed as they were supplied. Overhead cost is taken from the overhead cost/ft² table

TABLE 5.—Direct Inputs for Specific Crops.

Print Initials of Genus and Species
Read in Cost of Liner
Read in Container Information
  Read in Container Size: 1, 2 or 3
  Read in Container Material: Metal or Plastic
  Read in Container Labor: Manual or Mechanized
  Read in Container Mix: Commercial or Composted
Read in Cost of Canning
Read in the Code for Your Overwintering Method:
  1 = Single Poly
  2 = Double Poly
  3 = Double Poly and Heat
Read in Months to Grow in Year 1978
Read in Space (in²) Required in Year 1978
Read in Overwintering Costs for Year 1978
Read in Percent Shrinkage

TABLE 6.—Sample Output of Total Unit Production Cost.

Plant Name—Berberis thunbergi	Production Cost Dollars	Industry Av. Dollars
Direct Cost per Plant:		
Liner Cost	0.399	0.360
Canning Cost—1 Gallon Container	0.280	0.228
Indirect Cost per Plant for the Year 1978:		
Overwintering Cost	0.050	0.030
Overhead Cost (Space Adjusted)	0.554	0.347
Other Costs:		
Estimated Cost of Fertilizing	0.032	0.020
Estimated Cost of Weeding	0.030	0.019
Estimated Cost of Shifting	0.000	0.000
Estimated Cost of Pruning	0.032	0.020
Estimated Cost of Spacing	0.021	0.013
Total Cost	1.398	1.037
Cost of Shrinkage	0.154	0.104
Total Cost per Plant Adjusted for Shrinkage	1.552	1.141

(Table 4) and re-adjusted to reflect actual plant space use and to change overhead costs from a square foot basis to a per plant basis. For example, if the program user's overhead cost/ft^2 is $1.00 and each plant requires 1.5 ft^2, the per unit allocation of overhead cost would be $1.50 to reflect the unit's actual use of space. Other costs, such as fertilizing, weeding, shifting, pruning, and spacing are estimated as a fixed percent of production cost based on producer size classification and cultural group. The total cost per plant is calculated and printed for both the producer and industry average. Cost per plant is increased to include the cost of shrinkage, which has been fixed at 10% for the industry average. The final cost output is the total cost per plant adjusted for shrinkage.

After the cost/plant output has been made, the user has two options in section 5 (Fig. 1). Figure 3 presents these options in flowchart form. First, another crop can be analyzed. If another crop is to be analyzed, the program recycles to section 4 (Fig. 1), so that a new crop and direct costs can be read. All overhead costs remain as previously read.

If the user does not want to use the program for another crop, the user has the option of using the whole program again or ending the computer session (section 6, Fig. 1). If the program is to be re-used, the program recycles to the beginning and requests new data throughout the program. If the program is not to be used again, the computer session will be terminated.

Table 7 presents a summary of program inputs. All data for the program user are variable and directly input except for cost items such as fertilizing, weeding, shifting, pruning, and spacing, which are set as

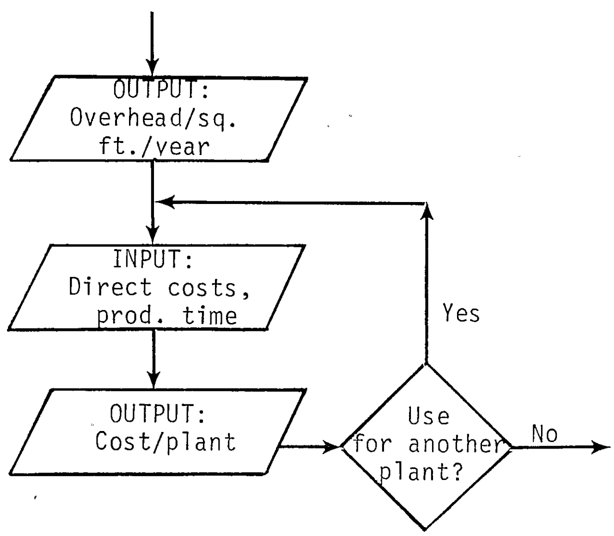

FIG. 3.—Recycling of program for use with another crop.

TABLE 7.—Program Input Summary.

Cost Factor	User	Industry Av.
Canning	Variable	Annual Fixed
Liner	Variable	Annual Fixed
Overwintering	Variable	Annual Fixed
Overhead	Variable	Annual Fixed
Other:		Annual Fixed
Fertilizing	Fixed Percent	
Weeding	Fixed Percent	
Shifting	Fixed Percent	
Pruning	Fixed Percent	
Spacing	Fixed Percent	
Av. Container Space	Variable	
Production Area	Variable	
Shrinkage	Variable	
Space Utilization	Variable	
Return on Investment	Variable	

a fixed percent of production cost based on producer size and cultural group classification. These costs were not found to be significant cost factors, as canning cost, liner cost, and overhead cost made up 80% or more of total production cost in most producer size and cultural group classifications in the study that the computer program is based (1, 4). All industry average data are fixed by producer size and cultural group classification. All fixed data are fixed on an annual basis and will be updated as more recent cost data become available.

RESULTS AND DISCUSSION

The program can be accessed from anywhere in the United States with a telephone and portable computer terminal. Output is received at the terminal, so the user receives immediate production cost analysis results. All data for the program are prepared before accessing the program, so that the cost of using the program is minimized. Detailed production cost information should aid nurserymen in evaluating the profitability of specific crops, making decisions concerning product mix, and evaluating their business' relative cost competitive position in comparison to businesses of similar size in the nursery industry.

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Timing of Autumn Fertilization on Container-Grown Cotoneaster

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ABSTRACT

The response of *Cotoneaster dammeri* 'Royal Beauty' to fertilizer treatments applied through six dates from August through November was studied. Plants were overwintered under three different types of winter protection: single layer poly, double layer poly with supplemental heat, and microfoam. Optimum growth and survival under single layer poly occurred with fertilizer treatments applied through Sept. 20. Storage of cotoneaster under double layer poly with supplemental heat (55° F) resulted in greater plant growth for plants fertilized through Nov. 30. With cotoneaster stored under microfoam, there were no differences in plant growth or survival with any of the fertilizer treatments. Fertilization through mid-September is recommended for fertilization of container-grown nursery stock in the Midwest if plants are stored without heat.

INTRODUCTION

The correct timing of fertilizer applications is receiving increasing attention throughout the country. Previous researchers (1, 9) have shown that correctly timed fertilizer applications will produce as much shoot growth as continuous fertilizer applications and at the same time reduce fertilizer requirements by approximately one-half.

One area of fertilization that is becoming increasingly important is autumn fertilization. Limited information is available concerning when autumn fertilizer applications should be terminated. Numerous studies are available which have determined that increased nitrogen applications in the autumn may or may not influence hardiness of container-grown nursery stock (3, 4, 6, 8). Spring growth, however, is dependent on storage nutrients which are accumulated before the spring growth flush begins (2, 5, 7); usually those nutrients are taken up by this plant in the autumn. The objective of this study was to determine the effects of fertilizer application applied through various dates on winter survival and spring growth of *Cotoneaster dammeri* 'Royal Beauty'.

MATERIALS AND METHODS

Rooted cuttings of 'Royal Beauty' cotoneaster were grown in a hardwood bark: sand medium 4:1 (v/v) under normal nursery conditions from May 15, 1978, until August 9, 1978. All plants received 200 ppm of N weekly, applied as Peters 20-20-20 soluble fertilizer. Starting on August 9, 18 plants were removed from the fertilization program on the following dates: August 16, Sept. 6 and 20, Oct. 20, Nov. 1 and 30. Thus treatments consisted of fertilizer applied through August 16, Sept. 6 and 20, Oct. 20, Nov. 1 and 30. No new growth occurred in the autumn after August 1 on any treatment.

On Dec. 4, six single plant replicates from each fertilizer treatment were placed in each of three winter storage units: single layer poly covered house, double layer poly covered house plus supplemental heat (55° F), and microfoam-copolymer covering. Eight weeks later the shoot number was counted and length measured on plants in the supplemental heat house. All plants were removed from winter storage units on April 1, 1979, and placed in a greenhouse under natural photoperiods with day/night temperatures of 75/68° F ± 5° F. Six weeks later visual rating and growth index data were taken. Winter damage was evaluated on a 0-4 scale, with 0

TABLE 1.—Effects of Autumn Fertilization on the Spring Growth Index of Cotoneaster dammeri 'Royal Beauty'.

Treatment Date	Growth Index (inches)*		
	Single Layer Poly	Minimum Heat	Microfoam
August 9	18	20	18
September 6	15	21	18
September 20	18	21	18
October 20	20	21	18
November 1	5	21	18
November 30	0	25	18
$LSD_{0.05}$	5.0	2.0	NS

$$\text{*Growth index} = \frac{\text{height} + \text{width}}{2}.$$

TABLE 2.—Effects of Autumn Fertilization on Overwintering Damage of Cotoneaster dammeri 'Royal Beauty'.

Treatment Date	Visual Evaluation		
	Single Layer Poly	Minimum Heat	Microfoam
August 9	2.4*	0.0	0.0
September 6	1.6	0.0	0.0
September 20	0.0	0.0	0.0
October 20	2.4	0.0	0.0
November 1	2.6	0.0	0.0
November 30	4.0	0.0	0.0

*0 = no damage, 4 = 100% damage. Values greater than 2.0 are considered commercially unacceptable for Cotoneaster dammeri 'Royal Beauty'.

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equaling no injury and 4 as 100% damage. A completely randomized design was used for this study.

RESULTS AND DISCUSSION

Severe winter damage occurred on plants stored in the single layer poly house when fertilizer was applied through the month of October (Tables 1 and 2). Data indicate that for optimum growth and minimum winter injury in single layer poly houses, fertilization should continue until the middle of September, when plants are grown under environmental conditions similar to central Ohio. Cessation of fertilizer applications to plants stored under single layer poly prior to September resulted in unacceptable plants as a result of overwintering damage (Table 2). These data suggest that overwintering damage is minimized if plants are in the proper nutritional status during the overwintering period. However, growth the following spring was not enhanced by fertilization beyond August when plants were stored under single layer poly.

Growth of cotoneaster was enhanced by late autumn fertilization (November) only when these plants were overwintered in a double layer house with supplemental heat. New growth began on these plants shortly after entering the overwintering structure in December; by January 30 new shoots on plants fertilized through November were considerably longer than other plants in the study (Table 3). In fact, when supplemental heat is used in the overwintering of container-grown plants, there may be some advantage to continued fertilization throughout the overwintering period if growth occurs in supplemental heat houses.

Plants overwintered under microfoam were similar in size and quality regardless of the timing of autumn fertilization (Tables 2 and 3).

This study was not designed to evaluate or recommend these three types of overwintering. Overwintering methods used in this study represent three types of winter protection which may or may not be suited for practical use in commercial nurseries

Various studies have suggested nitrogen reduces winter hardiness, increases winter hardiness, or has no effect on winter hardiness (3, 4, 6, 8). This study indicates that hardiness (evidenced by lack of winter damage) does decrease with fertilizer applications applied in late autumn; however, increasing the level of winter protection can adequately compensate for continued autumn fertilization. Cessation of fertilization in early August, which contributed to winter damage of plants when stored under single layer poly, did not affect subsequent spring growth of plants stored under single layer poly or microfoam.

This study indicates that once nutrients have accumulated after the last summer growth flush, fertilizer applications may cease. Spring growth was not enhanced by late autumn fertilization and, in fact, late autumn fertilization may actually contribute to damage during the overwintering period.

In summary, there is no advantage to continuing fertilizer applications past mid-September for container-grown cotoneaster when those plants have been adequately fertilized during the growing season, unless plants are being overwintered with supplemental heat.

TABLE 3.—Effects of Duration of Fertilizer Applications on Growth of Cotoneaster dammeri 'Royal Beauty' Occurring During Overwintering in Double Layer Poly Houses with Supplemental Heat (55° F).

Treatment Date	Number of New Shoots (per plant)	Length of New Shoots* (inches)
August 9	1.7	0.2
September 6	14.3	1.2
September 20	9.0	1.2
October 20	3.3	0.4
November 1	25.0	2.0
November 30	27.0	1.5

*Determined by measuring the length of the three longest shoots per plant.

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Nutrient Stability of Overwintered Container-Grown Ornamentals

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ABSTRACT

During overwintering, fluctuations of macronutrient levels in the leaves, stems, and roots of *Cotoneaster dammeri* C. K. Schneid. cv. Royal Beauty and *Juniperus horizontalis* Moench cv. Plumosa were studied. Phosphorus levels remained stable in all tissues, while tissue N levels fluctuated significantly throughout the sampling period in leaves, stems, and roots of both species. Potassium, Mg, and Ca tissue levels showed periods of relative stability in both species.

INTRODUCTION

Fertilizer applications, prior to the onset of dormancy, have been shown to influence growth (7, 12), indicating that values obtained for tissue nutrient levels during dormancy may reflect tissue nutrient availability in the spring. Thus, nutritional imbalances observed during overwintering could be indicative of the plant's nutrient requirement and these imbalances could be corrected by application of fertilizer prior to spring growth.

Information on macronutrient stability during overwintering is needed to determine if sampling during this period is satisfactory for diagnostic use. Several studies with deciduous and evergreen crops indicate that nutrient levels are unstable during the growing season (2, 5, 8, 14, 15). Stability of leaf nutrient levels during the winter months has been found with avocado (4, 11) and mango (10), and with Hicksi and Browni yew (9) during the fall and winter months. These data suggest that tissue nutrient levels in woody ornamentals sampled in late fall, winter, and early spring may be more stable than tissue nutrient levels in plants sampled during the growing season.

In the area of woody ornamentals, timing of the sampling procedure to coincide with periods of stability of tissue macronutrient levels has received limited attention (3, 9, 14). The purpose of this study was to determine if K, Mg, Ca, P, and N tissue levels in cotoneaster and juniper exhibit periods of stability during overwintering.

MATERIALS AND METHODS

On May 21, 1977, uniform 1-year-old cotoneaster and juniper liners were potted in 1-gallon plastic pots in a 2:1:1 (by volume) composted hardwood bark/sphagnum peat/sand medium and grown in a nursery. Plants were treated weekly with 200 ppm N, as 20-20-20 N-P-K soluble fertilizer, from May 30 until Oct. 1, 1977. Samples were taken twice monthly, from Oct. 14, 1977, through April 17, 1978. Two plants were selected and combined as one sample from each of four replications, using a completely randomized design. On Nov. 30, 1977, the plants were covered with single layers of ¼-inch DuPont microfoam and 4 mil white copolymer. Snow was allowed to accumulate on this covering between harvest dates.

After harvest, leaves, stems, and roots were forced-air dried at 70° C for 72 hr prior to recording the dry weights. Total N was determined by the micro-Kjeldahl method, P by the vandate-molybdate colorimetric procedure, Mg by atomic absorption spectrophotometry, and K and Ca by flame emission spectrophotometry. Periods of tissue nutrient stability were identified by determining ranges of nonsignificant fluctuations of nutrient values over time, using the Waller-Duncan K-ratio t-test at the 5% level (1).

RESULTS AND DISCUSSION

No significant fluctuations in K levels in cotoneaster leaf tissue were observed from late November to mid-April. Juniper leaf K levels were stable throughout the study, with the exception of the final sampling period (Fig. 1). Potassium levels in cotoneaster and juniper stems increased gradually after the plants were covered with the microfoam-copolymer blanket and then leveled off (Fig. 1). This increase may be due to the subsequent 81% reduction in light intensity caused by the covering (13). Previous work with American holly has shown an increase in leaf K levels when light intensity was reduced by 92% (6). The increase in cotoneaster stem K levels was more gradual than that of the juniper stems and resulted in three overlapping periods of stability (Fig. 2).

Juniper leaf Mg levels were stable throughout the sampling period, while levels in cotoneaster leaves fluctuated until mid-January, after which they stabilized (Fig. 1). Cotoneaster stems and roots each maintained two periods of stability of Mg levels (Fig. 2). Magnesium and K maintained similar periods of stability for leaves and stems of both species, indicating that factors affecting K levels may also affect Mg levels.

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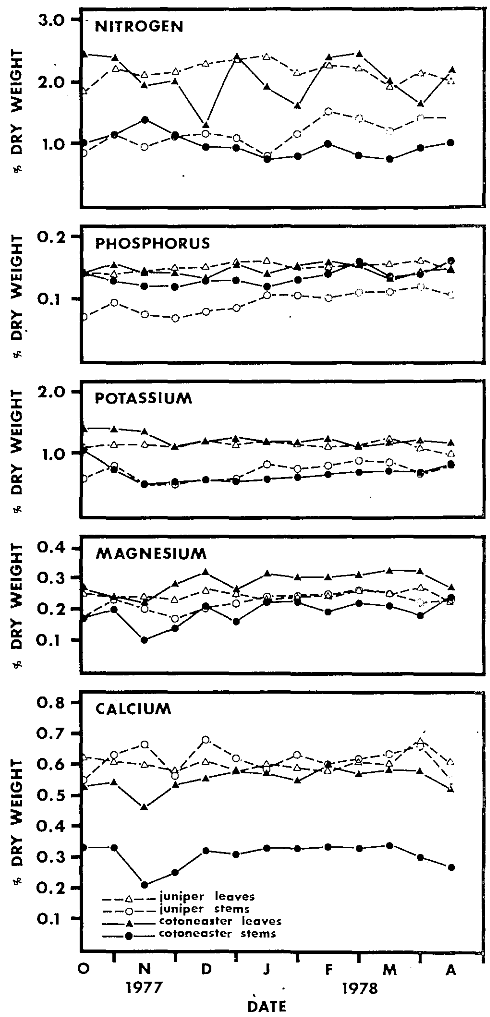

FIG. 1.—Fluctuations in mineral composition of leaves and stems of Cotoneaster dammeri cv. Royal Beauty and Juniperus horizontalis cv. Plumosa during overwintering.

Calcium levels in cotoneaster roots and juniper leaves were stable from mid-October to mid-March. Fluctuations of Ca levels in cotoneaster leaves and stems were similar; both were stable from mid-December to early April (Fig. 1). Significant changes in juniper root Ca levels occurred throughout the sampling period. Calcium levels in leaves of both species and in stems of cotoneaster had periods of stability similar to K and Mg.

Phosphorus was the most stable nutrient in both species. Research with Hicksi yew has shown similar P stability (9). Neither cotoneaster leaf and root nor juniper leaf P levels fluctuated significantly throughout the study (Fig. 1). Minor fluctuations in P levels occurring in cotoneaster stems and juniper stems and roots resulted in two periods of stability for each of these plant parts (Figs. 2 and 3).

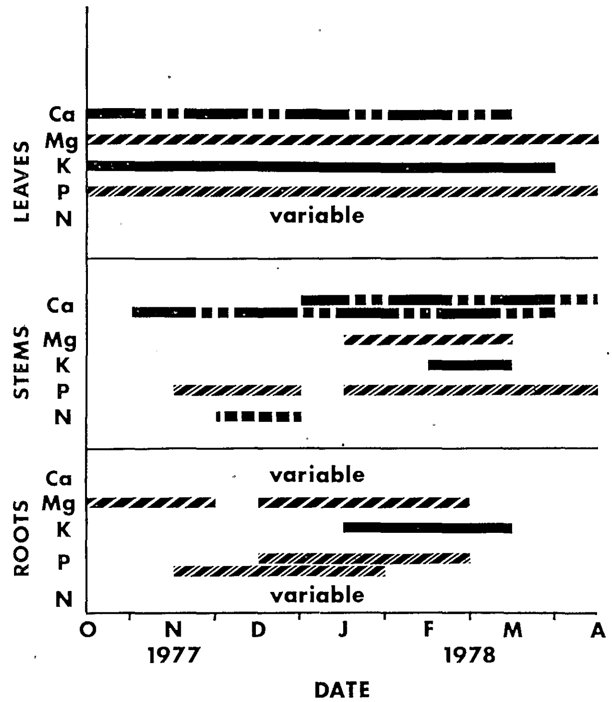

FIG. 3.—Periods of relative stability of N, P, K, Mg, and Ca levels in the roots, stems, and leaves of Juniperus horizontalis cv. Plumosa.

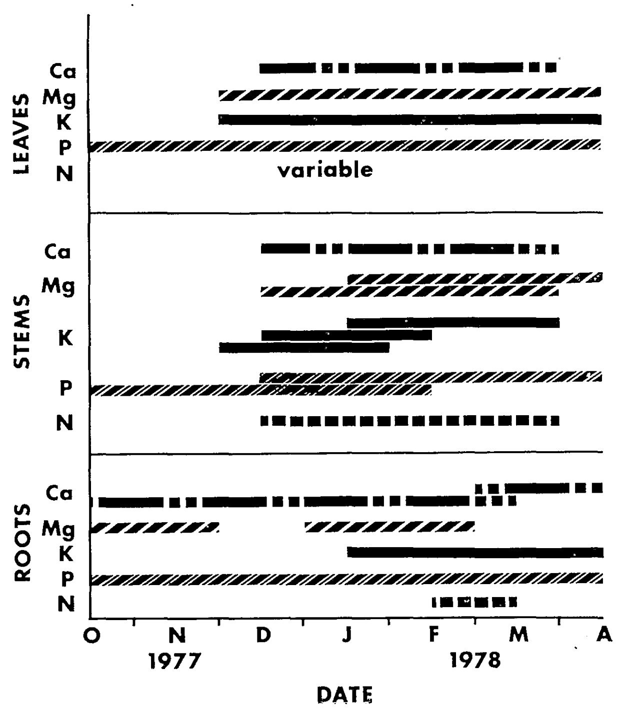

FIG. 2.—Periods of relative stability of N, P, K, Mg, and Ca levels in the roots, stems, and leaves of Cotoneaster dammeri cv. Royal Beauty.

No significant differences in the N levels in cotoneaster stems were observed from mid-December to early April (Fig. 1). With the exception of short periods of stability of cotoneaster roots and juniper stems (Figs. 2 and 3), N levels of all other samples fluctuated significantly throughout the sampling period.

Suitable sampling periods can be recommended for diagnostic tissue analysis for K, Mg, Ca, and P in leaves and stems of cotoneaster and juniper. Cotoneaster leaves should be sampled from mid-December to early April and juniper leaves from mid-October to mid-March. The sampling period for cotoneaster stems extends from mid-January to early April and for juniper stems from mid-January to mid-March. Sampling of roots for diagnostic tissue analysis is not recommended. As a result of this study, a sampling time for tissue N during the dormant period cannot be recommended.

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Air Blanket—A Material to Protect Plants in Quonset Storage Structures

ELTON M. SMITH, NORMAN LOWNDS, and SHARON A. TREASTER[1]

ABSTRACT

A product marketed as Air Blanket, a series of 4-inch clear polyethylene tubes bonded together in blanket form, was evaluated as a cover over nursery stock stored during winter in a single layer poly covered quonset house. The plants overwintered under the Air Blanket were in better marketable condition than control plants. Temperatures were higher under the Air Blanket when compared to other means of winter storage.

INTRODUCTION

Storage of container grown nursery stock under single layer, poly covered, quonset shaped, storage units is satisfactory protection for the majority of plants. However, certain species which are borderline in hardiness or susceptible to root injury at 20° F or above are often injured during the storage period (1). To assist in reducing injury, producers have added supplemental heat, but this procedure is expensive (3). Alternative techniques to heating include covering the structure with two layers of poly or covering the plants with an insulative material such as microfoam or a single layer of polyethylene (2).

A new product was introduced into the nursery industry during the winter season of 1978-79 to be used directly over the plants similar to microfoam and the poly liner. The product marketed as Air Blanket is a series of inflatable 4-inch clear polyethylene tubes bonded together in widths varying from 3 to 6 feet and available in lengths to 500 feet. Each blanket has a noninflatable flap 4 inches wide on one side and 1 inch on the other to be used in attaching blankets together by heat bonding or stapling.

A study was undertaken to compare the quality of selected container grown landscape plants following storage under the Air Blanket. A comparison of temperatures under the Air Blanket with other types of storage was also made.

MATERIALS AND METHODS

Storage structures located in a commercial nursery in New Carlisle, Ohio, were covered with single layer 4 mil white copolymer in early November. The Air Blanket was applied directly on the plants Dec. 22, 1978, and inflated with a shaded pole blower. In Ohio, this additional protection on the plants is needed only during the coldest weeks of winter, typically from Jan. 1 through the end of February. Two 5 ft widths were stapled together and placed over all the plants on one side of the house. Plants on the opposite side of the house were uncovered and served as the control area. The houses were 185 ft long x 20 ft wide with a 15-in aisle down the center.

Plant species evaluated were: *Berberis atropurpurea* 'Crimson Pygmy', *Cotoneaster apiculata, Euonymus kiautshovicus* 'Manhattan', *Hibiscus syriacus, Ligustrum* x *vicaryi, Magnolia* x Dr. Merrill, *Pinus mugo mugo, Pyracantha coccinea* 'Mohave', *Syringa* 'Charles Joly' and *Viburnum carlesi*. A minimum 10 plants/species were replicated in three locations within the house.

The temperature data were recorded daily at 10:00 a.m. at plant height in several houses, including those with double layer poly, additional heat, and microfoam. These values are included for comparison purposes.

The root, stem, and foliar tissue of the test plants were visually evaluated for injury on March 29, 1979.

RESULTS AND DISCUSSION

The weather conditions of the 1978-79 winter season were not as extreme as the two previous years. The lowest temperature recorded was —14° F on Jan. 10 and 11, and only 14 days of sub-zero temperatures were recorded at the nursery.

As a consequence of the relatively mild winter weather, plant injury was not extensive. Injury to certain plant species was evident, particularly the magnolia, Mohave firethorn, cranberry cotoneaster, mugo pine, and Korean spice viburnum (Table 1). On the average, no plants stored under the Air Blanket were considered unsalable. Both firethorn and magnolia in the control group had visual root injury which would render them unsalable.

Even though a rating of 7 is a salable plant, the objective is to achieve a rating of 9 or above which indicates a minimum of injury. Generally the plants evaluated under the Air Blanket had visual ratings of 9 or above for both the vegetative and root systems. Plants stored without this additional protection were injured to a greater extent, particularly the root systems.

The temperature data recorded during January

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TABLE 1.—Quality of Nursery Stock Following Storage for 3 Months in a Poly House with an Air Blanket Over the Plants.

		Plant Quality*			
		Air Blanket		Check	
Plant Materials	Container Size	Foliage	Root	Foliage	Root
Crimson Pygmy Barberry	1	7.3	10.0	7.3	10.0
Crimson Pygmy Barberry	2	9.7	10.0	9.7	10.0
Cranberry Cotoneaster	1	10.0	8.0	9.7	7.3
Cranberry Cotoneaster	2	10.0	8.3	9.7	8.0
Manhattan Euonymus	1	9.3	10.0	8.7	8.7
Manhattan Euonymus	2	10.0	9.3	9.3	8.7
Vicary Privet	1	10.0	9.7	10.0	9.7
Vicary Privet	2	10.0	9.0	9.7	9.3
Dr. Merrill Magnolia	2	10.0	8.3	10.0	6.3
Mugo Pine	2	10.0	9.0	9.3	7.3
Mohave Firethorn	2	9.3	7.0	7.7	6.7
Shrub Althea	2	10.0	10.0	10.0	10.0
Charles Joly Lilac	2	10.0	9.7	10.0	8.7
Koreanspice Viburnum	2	10.0	8.0	10.0	7.7
		9.7	9.0	9.3	8.4

*Visual evaluation score: 0 = plants dead; 10 = no injury, excellent quality. A rating of 7 is considered commercially salable.

and February, the two coldest months, indicate a marked difference in average values (Table 2). Temperature in the single layer poly house averaged 17° F while temperatures in the same house under the Air Blanket were 31.2° F. This 31.2° F is comparable to the 30.5° F temperature that was maintained in the minimum heat house with the thermostat set at 32° F. Temperatures under the Air Blanket covering averaged 6° warmer than temperatures under microfoam.

The improved plant quality and warmer temperatures obtained under the Air Blanket suggest continued investigations with this product. Two drawbacks may slow its acceptance in the nursery trade. First, its operation requires a shaded pole blower which is not expensive but electricity is not always available to storage houses. Second, the initial expense is currently higher than for microfoam and producers must weigh the improved quality likely to be obtained against the additional cost factor.

TABLE 2.—Average Daily Temperatures Inside Winter Storage Structures During January and February 1979.

Treatment	Degrees F.
Outside	7.4
Single layer poly	16.9
Single layer with microfoam	25.3
Single layer with Air Blanket	31.2
Double layer	22.9
Double layer with minimum heat (32° F)	30.5

ACKNOWLEDGMENTS

The authors wish to thank General Films of Sidney, Ohio, for supplying the Air Blanket and installation labor for this study. Thanks are expressed to the Studebaker Nursery for providing the overwintering structures and plants for this evaluation.

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Studies of Capillary Watering of Container Grown Nursery Stock[1]

ELTON M. SMITH and SHARON A. TREASTER[2]

ABSTRACT

Container size and type, media, and capillary mats were studied to determine growth differences in each system. Plant growth in plastic containers with drainage holes along the base was equal to containers with holes in the bottom when produced on a capillary mat. Different sizes and types of containers could be placed on the same capillary mat without affecting plant growth. Several different types of capillary mats were satisfactory as well as a 1½-inch sand base. Plant growth was acceptable in soil-peat-sand, hardwood bark-sand and pinebark-vermiculite mixes. Plant growth was superior in capillary treatments when compared to overhead and hand watering.

INTRODUCTION

Capillary watering is commonly utilized in England to produce container grown nursery stock (2) and has become a standard procedure for certain pot grown flowers in greenhouses in the United States. Advantages of capillary watering include less water consumption, less water run-off, and reduced potential for foliar diseases (1). This report includes a review of studies of capillary watering of nursery stock in which this technique has been evaluated on container grown nursery stock in outdoor beds.

MATERIALS AND METHODS

All studies were conducted in The Ohio State University container research nursery during the growing seasons of 1976-1978 on beds 5-ft wide x 50 ft long. The studies were conducted on a gravel base with a slight crown along the main bed axis to provide drainage away from the capillary mat or base. A layer of poly film was placed over the gravel which had been smoothed. The poly of any color or thickness retains the moisture and allows its distribution under the mat or sand base. The capillary mat or sand was placed on the poly with the plants placed on top. Very low water pressure of 4-6 psi was utilized to operate the Chapin twin wall trickle tubing which kept the mat or sand moist for 4 hours per day. The trickle tube was operated with a time clock and solenoid valve to reduce labor.

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1976 Study—An Evaluation of Container Types, Sizes, and Capillary Mats

Objectives of these studies were to evaluate the growth of *Cotoneaster dammeri* 'Royal Beauty' produced in two container types and two container sizes on several capillary mats.

Zarntainer No. 300 (1 gal) and No. 800 (2 gal) with holes along the base and one in the underside and Polytainer No. 1 (1 gal) and No. 2 (2 gal) with holes only along the base were used, along with a commercial pinebark-vermiculite medium. The mats evaluated were water-mat (Pellon Corp.), Vattex-P (U. S. Vattex), Weed-Chek (Certain-Teed), and Eddymat (F. R. Young Co.). All plants were irrigated from overhead at the time of placement on the mats to initiate capillary action. Plants were also irrigated from overhead an average of once a week in the absence of rainfall to reduce the tendency of salts build-up in the media. The study was conducted from April 23-Oct. 8, 1976. There were four

TABLE 1.—Growth of Royal Beauty Cotoneaster Produced in Different Container Types and Sizes on Four Capillary Mats.*

	Dry Weight (Grams)				
	1 Gallon		2 Gallons		
Capillary Mat	Polytainer	Zarntainer	Polytainer	Zarntainer	Average
Water-Mat	62.7a†	49.4a	171.9a	216.8a	125.2
Vattex-P	41.5c	33.5a	132.4ab	190.1a	99.4
Weed-Chek	44.0bc	51.6a	80.4b	164.0a	85.0
Eddymat	53.9ab	43.6a	112.7b	189.9a	100.1
Average	50.0	44.6	124.4	190.4	

*Figures represent averages of six plants/can type and size from each of three replications.
†Mean separation within columns by Duncan's multiple range test, 5 % level.

container types, four capillary mats, and three replications of six plants each.

RESULTS AND DISCUSSION

Capillary mats can be utilized, with supplemental overhead irrigation as needed, to satisfactorily produce container grown cotoneaster outside under nursery conditions. Different size containers and different types of containers can be adequately produced on the same mat (3).

In almost all cases, vegetative growth was equal or greater in the 1-gal Polytainers. However, growth in the 2-gal Zarntainers was greater than that from plants in Polytainers.

Plant growth in containers with drainage holes along the base does not differ from containers with holes in the underside. Growth of plants was generally satisfactorily from all mats evaluated. However, plants were larger from the water-mat treatments. Drying of the mats after the water was turned off was more pronounced in the Weed-Chek treatment.

1977 Study—An Evaluation of Irrigation Methods and Production Medium

The primary objectives were to compare the growth and irrigation labor costs of watering by hand, overhead sprinklers, and capillary mat.

The capillary mat was the Pellon water mat kept moist by Chapin Twin Wall trickle irrigation tube. A second objective was to compare growth of plants grown in bark-sand (5:1 v/v) and soil-peat-sand (1:1:1 v/v) on the capillary mats. The plant materials were *Juniperus horizontalis* 'Wiltoni', *Euonymus vegetus, Cotoneaster dammeri* 'Royal Beauty', and *Cotoneaster apiculata.* All plants were grown in 1 and 2-gallon Polytainers. Plants were potted in April, put under capillary watering May 10, and evaluated Sept. 15. There were three species, two container sizes, and three replications of five plants each.

As shown in Table 2, all plant species in both 1 and 2-gallon cans produced on capillary mats were larger than those in the other two methods. The increased growth is most likely a direct result of uniform moisture conditions from daily irrigation. The plants watered by hand or by overhead sprinklers were watered only when the surface of the soil indicated a need. Plant growth, on the average, under overhead sprinklers was superior to plants watered by hand.

Hand watering required seven times as much labor to irrigate during the season as the overhead and sub-irrigation systems which were approximately equal in labor requirements. Installation of a capillary system will require additional initial labor for grading and mat or sand placement. A time clock and solenoid valve regulated the capillary mat system and a manual timer controlled the duration of the overhead sprinkler system.

TABLE 2.—Growth of Woody Ornamentals Produced by Capillary Mat, Hand, and Overhead Methods of Irrigation.*

Irrigation Method	Fresh Weight (Grams): Blue Rug Juniper		Bigleaf Euonymus		Royal Beauty Cotoneaster		Cranberry Cotoneaster	
	1 Gal	2 Gal	1 Gal	2 Gal	1 Gal	2 Gal	1 Gal	2 Gal
Capillary Mat	141a†	173a	102a	100a	127a	151a	147a	186a
Overhead	89b	157ab	65b	74a	81b	101b	89b	137b
Hand	83b	117b	62b	84a	69b	114b	76c	106c

*Figures represent averages from five plants/species/container size for each of three replications.
†Mean separation within columns by Duncan's multiple range test, 5% level.

TABLE 3.—Growth of Woody Ornamentals Produced in Bark-Sand and Soil-Peat-Sand Media on Capillary Mats.*

Container Media	Fresh Weight (Grams): Blue Rug Juniper		Bigleaf Euonymus		Royal Beauty Cotoneaster		Cranberry Cotoneaster	
	1 Gal	2 Gal	1 Gal	2 Gal	1 Gal	2 Gal	1 Gal	2 Gal
Bark-Sand	111b†	117b	70b	86a	109b	150a	138a	173a
Soil-Peat-Sand	171a	229a	134a	113a	144a	151a	156a	198a

*Figures represent averages from five plants/species/container size/media for each of three replications.
†Mean separation within columns by Duncan's multiple range test, 5% level.

The four plant species in both 1 and 2 gal sizes grew better in the soil-peat-sand mix than the hardwood bark-sand media (Table 3). Hardwood bark and sand has a greater tendency to dry faster than a soil-peat-sand mix. The more uniform moisture of the soil-peat-sand media is the probable reason for the superior growth.

All plants in the capillary mats were watered overhead approximately once a week to prevent soluble salts build-up.

1978 Study—An Evaluation of Capillary Mat vs. Sand Base and Trickle Tube Placement

The 1978 studies were designed to compare the growth of woody ornamentals produced on a capillary mat and on sand.

Chapin Twin Wall trickle tubes were placed on the Pellon water mat and on one and under the other sand treatment. All sand beds were 1½ inches thick with a plastic liner underneath. All plants were canned into 1-gallon Zarntainers with a commercial pine bark-vermiculite mix and 7½ lb of 8-9 month fertilizer (18-6-12) incorporated/yd^3 of the media. The plant materials were *Juniper horizontalis* 'Wiltoni', *Cotoneaster dammeri* 'Royal Beauty', and *Weigela* 'Newport Red'. The study was initiated May 15, 1978, and terminated Sept. 25, 1978. There were 10 plants per treatment per species with three replications.

Cotoneaster and juniper grew best on the capillary mat as shown in Table 4. The weigela growth was most satisfactory on the sand base treatments because it rooted into the sand and the plants were not disturbed during the season. Neither the cotoneaster nor juniper rooted into the sand during the evaluation period. Growth of all three plant species was superior in the sand irrigated from below. This treatment was more uniformly moist than the treatment with the tubes on the sand.

TABLE 4.—Growth of Woody Ornamentals Produced with Trickle Tube Irrigation on Capillary Mat and Sand Beds.*

	Fresh Weight (Grams)		
Plant Species	Capillary Mat	Trickle Tubes on Sandbase	Trickle Tubes Under Sandbase
Cotoneaster	179	142	152
Juniper	51	40	50
Weigela	160	209	217

*Figures represent averages from 10 plants/treatment/species/replication.

Growing plants on a sand base kept moist with trickle irrigation may have commercial production application with rhododendron, azalea, juniper, and other shallow rooted plants, but possibly not the rapid growing shrubs.

Capillary watering may have application in commercial container production and in garden centers or other retail areas to irrigate plants on sales display and greatly reduce or possibly eliminate the need for overhead watering.

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An Evaluation of Pigmented Films for Overwintering Landscape Plants

ELTON M. SMITH and SHARON A. TREASTER[1]

ABSTRACT

The quality of container grown nursery stock was evaluated following 4 months' winter storage under films ranging from 50 to 90% opacity. The most effective opacity ranges for white films were 80, 85, and 93%, while the most effective aluminum films were 71, 76, and 87% opacity. Night temperatures were similar under all films and day temperatures were lower under aluminum film. The higher the opacity of white film, the lower the day temperature.

INTRODUCTION

Most container grown landscape plants together with autumn harvested field potted plants and an increasing number of B & B evergreens are overwintered under some type of plastic cover. The nursery industry now has a selection of films in the marketing channels with differences in thickness, anticipated life expectancy, break strength, color, and other physical parameters (3).

Most of the white copolymer films used by the nursery industry have an opacity of 50 to 60%. This degree of pigmentation has proven to be satisfactory for the storage of most landscape plants and definitely superior to clear films which have been painted (1). However, in previous studies when the percent opacity varied between 70 and 90, the quality of stored container stock improved (2, 4).

The objectives of this investigation were to evaluate the relationship between film opacity and the quality of stored landscape plants.

MATERIALS AND METHODS

The study was conducted in storage huts measuring 10 ft x 6 ft x 4 ft in height located in The Ohio State University container research nursery in Co-

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TABLE 1.—Quality of Landscape Plants Following Storage Under Pigmented Polyfilm.

Film Color	Percent Opacity	Injury Ratings											
		Japanese Holly	Royal Beauty Cotoneaster	Burkwood Viburnum	Leatherleaf Viburnum	Common Boxwood	Weigela	Tallhedge Buckthorn	Early Cotoneaster	Laland Firethorn	Blue Rug Juniper	Spring Glory Forsythia	Average
Aluminum													
	87	10*	10	10	10	10	10	10	10	10	10	10	10.0
	76	8	10	10	10	10	10	10	10	10	10	10	9.8
	71	6	10	10	10	7	10	10	9	10	10	10	9.3
	64	1	2	10	10	8	10	10	10	10	10	10	8.2
	58	4	7	9	8	7	10	10	9	9	10	9	8.3
	53	1	2	10	4	10	8	10	8	10	10	8	7.3
Black													
	100	1	3	1	10	5	9	9	8	8	10	9	6.6
Clear													
	5	1	1	1	1	2	5	4	4	2	3	3	2.4
White													
	93	4	10	10	10	10	10	10	10	10	10	10	9.4
	85	5	9	10	10	9	10	10	10	10	10	10	9.4
	80	6	8	10	10	10	10	10	10	10	10	10	9.4
	70	4	10	10	10	10	10	10	10	10	10	10	9.4
	60	2	10	10	6	8	10	10	10	10	10	10	8.7
	50	1	6	8	6	8	10	8	6	8	10	6	7.0

*Figures represent a visual evaluation on a 1-10 scale, with 1 = dead, 7 = commercially salable, and 10 = excellent quality. All figures represent an average of three plants/treatment with three replications.

lumbus. The plants and huts were covered with 4 mil film on Dec. 7, 1978, and the plants were evaluated on April 16, 1979. All films were supplied and pigmented to specifications of approximately 50 to 90% opacity by Canadian Industries Ltd., Ontario, Canada. There were 14 films (Table 1) evaluated, with three replications per film.

The 1 gallon container grown plant materials evaluated included *Buxus sempervirens, Cotoneaster apiculata, Cotoneaster dammeri* 'Royal Beauty', *Forsythia intermedia* 'Spring Glory', *Ilex crenata, Juniperus horizontalis* 'Wiltoni', *Pyracantha coccinea* 'Lalandi', *Rhamnus frangula* 'Columnaris', *Viburnum burkwoodi, Viburnum rhytidophyllum,* and *Weigela florida.* There were three plants/species/hut with three replications. Foliage was evaluated on a 10 point visual scale, with 7 considered salable but values of 9 and above most desirable. Temperature was recorded continually with a Honeywell Multipoint Recorder.

RESULTS AND DISCUSSION

Plant Quality Evaluation

Plant materials stored under most but not all film coverings were commercially salable. Both black and clear films resulted in unacceptable plants. However, most pigmented white and all aluminum films were acceptable plant covers as shown in Table 1.

The 100% black film caused a considerable degree of foliage blackening and defoliation of broadleaf evergreens, including Japanese holly, Burkwood viburnum, Royal Beauty cotoneaster, and common boxwood. The narrowleaf evergreens and deciduous shrubs were not severely damaged. Most likely the damage resulted as a function of the rate of respiration exceeding photosynthesis and almost all food reserves became depleted.

The 5% clear films transmitted 95% of the light and the huts became quite warm, with temperatures exceeding 100° F in March. The high temperatures led to desiccation of the plant tissue as no additional water was supplied to those plants.

Generally, the higher the percent of pigmentation of aluminum film the better the quality of stored nursery stock. Film pigmented at the 53% opacity level resulted in an average evaluation of 7.3, while plants stored under film at the 87% opacity level were all in excellent foliar condition.

The lower the opacity of white film, the more plant injury was manifested. However, once the opacity was increased to 70% or higher, the plant quality was most satisfactory.

Since the objective of winter storage is to overwinter with a minimum of injury, it appears that a minimum of 70% opacity is required for both white and aluminum films. Although not evaluated in this study, tensile strength of white film is reduced when the opacity is increased to 90% or above with titanium oxide. For that reason the apparent optimum opacity range for white film for nursery stock storage will be between 70 and 90%.

TABLE 2.—Temperatures During Storage Under Pigmented Poly Films.

Film Color	Percent Opacity	Av. Day Temperature* °F	Av. Night Temperature* °F
Aluminum	87		18.7
	76	54.3	17.8
	71	56.8	18.0
	64	51.5	18.0
	58	53.0	17.6
	53	53.5	18.3
Black	100	58.0	16.0
Clear	5	67.8	17.5
White	93	54.3	18.1
	85	59.4	16.9
	80	61.5	17.9
	70	62.1	18.1
	60	64.3	18.3
	50	64.8	18.3
Outside		58.7	7.1

*Figures represent averages from the three warmest and three coldest dates during December 1978, January-March 1979. Temperatures were recorded at 3:00 p.m. for high and 3:00 a.m. for low readings.

Temperature Fluctuations

The average night temperatures (3:00 a.m.) in the huts for the three coldest nights in December, January, February, and March were very similar (Table 2). The difference between the coldest and warmest of the average night temperatures was only 2.7° F. The black film averaged 16.0° F and the 87% aluminum film averaged 18.7° F. There were no temperature trends in either of the pigmented series of films to indicate a relationship of degree of pigmentation to average low temperature. All films resulted in an average 10° F increase in average night temperature over outside temperatures.

The average day temperatures (3:00 p.m.) in the huts for the three warmest days each month from December-March were similar in the aluminum films and decreased with increasing film opacity of the white film (Table 2). The difference between the coolest daytime high of 51.5° (64% auminum) and warmest daytime high of 67.8° (clear) was 16.3° F. All aluminum films resulted in an average daytime temperature of 53.8° F which was 5.1° lower than outside temperatures. The average daytime high temperature of white film covered huts was 61.1° or 2.4° F warmer.

The objective of nursery storage is to control temperatures insofar as possible by maintaining a high night temperature and low day temperature. The higher the night temperature, the less the chance of freezing injury; the lower the day temperature, the less chance of desiccation injury of the nursery stock.

From these studies there is very little difference in average night temperatures among structures covered with the various pigmented films. The aluminum films maintain cooler structures during the day than white films. The day temperatures under white film decreased with increasing opacity, the most likely factor in the improved plant quality under the darker films.

SUMMARY

Poly films for nursery storage pigmented in white and aluminum over a range of opacities from 50 to 93% were evaluated as coverings over container grown nursery stock. Excellent plant quality was obtained from 4-month storage under white films pigmented at 70, 80, 85, and 93% opacity. Similar quality was obtained under aluminum film pigmented at 71, 76, and 87% opacity. Plant quality was unacceptable following storage under clear and black films. Night temperatures were relatively stable under all films. Day temperatures were cooler under aluminum than white film. The higher percent opacity of the white film, the lower the day temperatures; this feature is nearly as desirable as high night temperatures.

Continued research is underway in walk-in size quonset huts to further refine the most desirable percent opacity of white and aluminum storage film.

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Evaluation of Post-transplant Herbicides for Phytotoxicity and Weed Control in Annual Bedding Plants

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ABSTRACT

The herbicides alachlor (Lasso), trifluralin (Treflan), oryzalin (Surflan), and oxadiazon (Ronstar) were applied at rates of ½, 1, 2, and 4 times that recommended on 13 species of annual bedding crops and evaluated for weed control and phytotoxicity. Alachlor at 4.0 lb ai/A and trifluralin at 2.0 lb ai/A significantly injured begonia and salvia transplants. Oryzalin at the recommended rate of 4.0 lb ai/A injured the coleus and salvia, while oxadiazon at a rate of 2.0 lb ai/A injured both pansy and snapdragon. None of the herbicides used at the recommended rate gave satisfactory control of crabgrass.

INTRODUCTION

Control of annual grass and broadleaf weeds in and around displays of annual bedding plants is a serious problem, most often accomplished by laborious and costly handweeding. Previous research has demonstrated that DCPA (Dacthal), used as a preemergent herbicide, resulted in no apparent phytotoxicity to either direct seeded or transplanted annual bedding plants (1, 2).

Haramaki and Atmore (4) reported satisfactory preemergent weed control, with no phytotoxicity, on transplanted marigolds 10 weeks after applications of diphenamid (Dymid), trifluralin (Treflan), and EPTC (Eptam). Research in 1970 and 1971 noted that preemergent trifluralin at 2.0 lb ai/A resulted in satisfactorily control of annual grasses with no phytotoxicity to transplanted petunias, geraniums, ageratum, snapdragons, and marigolds (2).

In a more recent study, Fretz (3) observed that alachlor (Lasso) at 3.0 lb ai/A, diphenamid at 6 lb ai/A, and napropamide (Devrinol) at 3.0 ai/A resulted in excellent preemergent broadleaf and grass weed control in plantings of transplanted annual bedding plants. Alachlor, however, caused significant injury to salvia, while the application of diphenamid caused moderate injury to celosia. Both trifluralin and DCPA provided less than acceptable control of broadleaf weeds at rates of 2.0 and 10.0 lb ai/A, respectively, but neither caused any significant phytotoxicity to any of the 15 species of transplanted annual bedding plants used in the study.

This study was designed to evaluate four herbicides for phytotoxicity and weed control in transplanted annual bedding plants.

MATERIALS AND METHODS

This study was conducted during the summer of 1979 on a Hoytville clay loam soil on The Ohio State University Horticulture Farm in Columbus. This soil had a pH of 7.0 and approximately 3.0% organic matter. During the spring prior to planting, 1,000 lb/A of 12-12-12 was applied and plowed down to a depth of 6-8 inches.

Eight plants of each of the 13 cultivars were transplanted into replicated plots on May 21, 1979. Immediately following transplanting, all plots were irrigated with ½ inch of water. Bedding plants were commercially produced from seed in 6/12 cell packs and were approximately 8 weeks old when transplanted.

Herbicides were applied on June 13, 1979, with a modified lawn fertilizer applicator. All plots were handweeded prior to herbicide application.

Herbicide formulations used in this study are listed in Table 1. Herbicide rates were selected so that each was applied at ½, 1, 2, and 4X the recommended rate, in order to obtain data on phytotoxicity and the degree of safety involved with the application. Of the herbicides evaluated, only trifluralin is labeled for use on a wide assortment of ornamentals including

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TABLE 1.—Common, Trade, and Chemical Names of Herbicides Used on Transplanted Annual Bedding Plants.

Common Name	Trade Name and Formulation	Chemical Name
Alachlor	Lasso-15G	2-chloro-2',6'-diethyl-N-(methoxymethyl) acetanilide
Trifluralin	Treflan-5G	α-α-α-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine
Oryzalin	Surflan-5G	3,5-dinitro-N^4,N^4-dipropylsulfanilamide
Oxadiazon	Ronstar-4G	2-tert-butyl-4-(2,4-dichloro-5-isopropoxyphenyl) Δ^2-1,3,4-oxadiazolin-5-one

TABLE 2.—Visual Evaluation of Phytotoxicity to Transplanted Annual Bedding Plants Treated with Various Post-transplant Herbicides.

Treatment and Formulation	Rate (lb ai/A)	Visual Phytotoxicity Rating*					
		Blue Blazer Ageratum	Carpet of Snow Alyssum	Pink Tauscendschon Begonia	Gold Tone Chrysanthemum	Velvet Rainbow Coleus	Sprinter Red Geranium
Alachlor-15G	2.0	4.2	1.5	4.8	1.5	2.5	1.5
	4.0	3.0	2.5	7.2	2.0	3.2	2.5
	8.0	3.5	4.0	7.8	3.0	4.8	3.0
	16.0	3.8	4.2	9.0	3.2	7.0	3.0
Trifluralin-5G	1.0	3.0	4.2	2.0	1.5	3.8	2.0
	2.0	2.5	2.0	4.0	1.0	3.5	1.5
	4.0	2.2	1.5	3.0	1.5	5.2	2.5
	8.0	3.2	2.0	3.2	1.0	5.8	2.8
Oryzalin-5G	2.0	2.0	2.8	2.8	1.0	4.2	1.5
	4.0	2.5	2.5	3.2	1.5	4.0	1.5
	8.0	2.2	2.8	4.5	1.5	6.5	3.0
	16.0	3.2	3.8	6.5	3.0	6.8	2.2
Oxadiazon-4G	1.0	1.5	2.0	2.5	1.5	2.2	2.2
	2.0	2.2	2.5	3.5	1.5	3.8	2.0
	4.0	3.2	4.8	6.2	1.0	5.5	2.0
	8.0	2.8	5.0	8.2	1.0	4.8	2.0
Check (non-weeded)		2.8	2.0	2.0	1.0	3.0	2.5
$LSD_{0.05}$		N.S.	1.4	1.5	0.7	1.4	N.S.

Treatment and Formulation	Rate (lb ai/A)	Visual Phytotoxicity Rating*						
		Twinkles Impatiens	Gypsy Sunshine Marigold	Majestic Mix Marigold	Red Cascade Petunia	Sentinel Salvia	Rocket Mix Snapdragon	State Fair Zinnia
Alachlor-15G	2.0	1.5	1.5	2.2	2.5	6.5	4.2	2.5
	4.0	2.5	2.8	2.2	3.0	7.8	5.0	3.2
	8.0	3.8	3.8	3.2	3.5	9.0	5.2	3.8
	16.0	4.8	4.5	2.2	3.5	10.0	4.8	5.0
Trifluralin-5G	1.0	2.0	2.0	2.8	1.5	2.5	3.8	2.5
	2.0	1.0	2.0	3.8	3.5	4.5	4.0	2.0
	4.0	2.2	2.2	3.2	2.0	4.0	4.2	1.5
	8.0	2.0	2.0	4.5	4.0	5.0	3.0	4.2
Oryzalin-5G	2.0	1.5	1.0	2.8	3.2	2.0	3.2	1.5
	4.0	1.5	2.0	1.5	3.0	4.2	3.5	2.5
	8.0	2.5	2.0	3.0	3.2	4.2	5.0	2.8
	16.0	2.8	2.2	3.0	5.5	7.2	5.8	4.2
Oxadiazon-4G	1.0	3.2	2.5	4.0	3.2	1.0	3.2	3.0
	2.0	1.5	1.5	4.2	3.5	3.2	4.5	1.5
	4.0	3.8	2.0	4.8	4.2	3.0	2.2	2.0
	8.0	7.8	2.8	7.8	5.8	6.5	4.5	4.8
Check (non-weeded)		1.5	1.5	1.8	2.5	2.2	2.5	1.5
$LSD_{0.05}$		1.1	0.9	1.2	1.2	1.6	N.S.	1.1

*Visual rating scale: 1.0 = no injury; 10.0 = complete kill.

annual bedding plants. All of the other herbicides evaluated are labeled for ornamental crops, but *not* annual bedding plants.

Annual bedding plants used in this study included blue blazer ageratum *(Ageratum houstonianum)*, carpet of snow alyssum *(Alyssum maritimum)*, pink tausendschon begonia *(Begonia semperflorens)*, gold tone chrysanthemum *(Chrysanthemum morifolium)*, velvet rainbow coleus *(Coleus blumei)*, sprinter red geranium *(Pelargonium hortorum)*, twinkles impatiens *(Impatiens sultanii)*, Gypsy sunshine marigold *(Tagetes patula)*, majestic mix pansy *(Viola tricolor)*, red cascade petunia *(Petunia hybrida)*, sentinel salvia *(Salvia splendens)*, rocket mix snapdragon *(Antirrhinum majus)*, and state fair zinnia *(Zinnia elegans)*.

Weed control and phytotoxicity ratings were recorded using a visual rating scale, with 1.0 representing no control or crop injury and 10.0 representing complete weed control or complete crop kill. A value of 7.5 or better was considered as acceptable weed control while a phytotoxicity rating of 3.5 or greater was indicative of an injury level considered unacceptable. At the time of the weed control evaluations, only the large crabgrass (*Digitaria sanguinalis*) population was sufficiently uniform throughout the plots to warrant evaluation. Weed control and phytotoxicity evaluations were obtained on July 19, 1979.

The study was designed as a randomized complete block with four replications of each treatment. Individual plots measured 6 x 50 feet and included eight plants of each species planted in rows 2 feet apart on 8-inch centers.

RESULTS AND DISCUSSION

An evaluation 1 month after application revealed that significant phytotoxicity occurred to many of the species employed in this study. Alachlor at the recommended rate of 4.0 lb ai/A was safe and caused little or no phytotoxicity on most of the species employed; however, the pink tauscendschon begonia, sentinel salvia, and rocket mix snapdragon were significantly injured. As the rate of the alachlor increased to 8.0 and 16.0 ai/A, or 2 and 4X the normal application rate, the level of phytotoxicity increased. Blue blazer ageratum, gold tone chrysanthemum, sprinter red geranium, majestic mix pansy, and red cascade petunia were all tolerant of the two higher rates of alachlor. All other species employed in this study exhibited varying degrees of phytotoxicity to the high rates of alachlor such that they were in unacceptable condition (Table 2).

Response to the recommended rate of trifluralin was as expected. When employed at the 2 lb ai/A rate, the pink tauscendschon begonia, sentinel salvia, and rocket mix snapdragon were significantly injured in comparison to the control plots. As the rate of trifluralin application increased to 4.0 and 8.0 lb ai/A, injury became apparent on the velvet rainbow coleus, majestic mix pansy, red cascade petunia, and state fair zinnia (Table 2).

Only the velvet rainbow coleus and the sentinel salvia were injured significantly when treated with the 4.0 lb ai/A rate of oryzalin. As the rate of the oryzalin increased to 8.0 and 16.0 lb ai/A, the pink tauscendschon begonia, red cascade petunia, rocket mix snapdragon, and state fair zinnia exhibited increasing phytotoxicity (Table 2).

When employed at the recommended rate of 2.0 lb ai/A, the oxadiazon was safe on a wide variety of annual bedding plants; however, sufficient phytotoxicity at this rate did occur to the majestic mix pansy and rocket mix snapdragon. As the rate of oxadiazon application increased to 2 and 4X the recommended rate, significant phytotoxicity was observed on the carpet of snow alyssum, pink tauscendschon begonia, velvet rainbow coleus, twinkles impatiens, majestic mix pansy, red cascade petunia, sentinel salvia, rocket mix snapdragon, and state fair zinnia (Table 2).

The phytotoxicity noted in this study at the higher than recommended rates was expected. Overall, the pink tauscendschon begonia, velvet rainbow coleus, and sentinel salvia were the most sensitive species to all herbicides at all rates used. In the case of the salvia this was as expected, since in a previous study (3) St. John's Fire Salvia was extremely sensitive to most herbicides employed including trifluralin and alachlor. Likewise petunias, geraniums, ageratum, chrysanthemum, marigold, and zinnia were tolerant of most preemergent herbicides when used at a low rate (3).

In terms of weed control, none of the products tested gave satisfactory control of the large crabgrass at the X or recommended rate. In the case of alachlor and oryzalin, only when the rate of application was increased to the 2X level was the control sufficient enough to be considered as satisfactory. The 4X rate of trifluralin (8.0 lb ai/A) resulted in satisfactory control of the large crabgrass, while none of the rates of the oxadiazon gave sufficient crabgrass control (Table 3).

The results observed might well be expected, since each of the herbicides was applied in a granular formulation, and distribution of the granules was a severe problem. It must also be realized that the granules must dissolve prior to weed seed germination in order to be effective, and this may not have occurred rapidly enough to obtain satisfactory weed control in this study. The results with trifluralin and alachlor do not agree with those obtained in a previous

TABLE 3.—Effectiveness of Several Herbicides on the Control of Large Crabgrass in Transplanted Bedding Plants.

Treatment and Formulation	Rate (lb ai/A)	Percent Large Crabgrass Control
Alachlor-15G	2.0	48.0
	4.0	52.0
	8.0	82.0
	16.0	75.0
Trifluralin-5G	1.0	30.0
	2.0	30.0
	4.0	62.0
	8.0	70.0
Oryzalin-5G	2.0	30.0
	4.0	52.0
	8.0	90.0
	16.0	72.0
Oxadiazon-5G	1.0	32.0
	2.0	35.0
	4.0	48.0
	8.0	68.0
Check (non-weeded)		12.0

study in 1976 (3), where both herbicides provided excellent overall weed control. However, in that case the herbicides were applied in the EC formulation. This may have resulted in better coverage and thus better weed control.

Overall, results of this study indicated that satisfactory weed control can be obtained in beds of transplanted annual bedding plants with little or no phytotoxic effects if moderate rates of herbicide application are used.

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Evaluation of Oxyfluorfen for Weed Control and Phytotoxicity on Container Grown Nursery Stock

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ABSTRACT

Oxyfluorfen-2G was evaluated for weed control and phytotoxicity on nine species of container grown nursery stock. Treatments included oxyfluorfen-2G applied singly at rates of 1.0, 2.0, 4.0 and 8.0 lb ai/A and in combination at 2.0 lb ai/A with simazine-4G at 1.0 lb ai/A, oxadiazon-4G at 4.0 lb ai/A, oryzalin-5G at 4.0 lb ai/A, and prodiamine-4G at 3.0 lb ai/A. Oxyfluorfen-2G when applied singly at the recommended rate of 2.0 lb ai/A did not control annual grass or broadleaf weeds. However, when oxyfluorfen-2G was applied at the 2.0 lb ai/A rate in combination with simazine, oxadiazon, oryzalin, or prodiamine, weed control was improved, with a minimum of injury observed. Oxyfluorfen-2G at the 2.0 lb ai/A rate in combination with any of the above four herbicides shows promise and should be further evaluated.

INTRODUCTION

Previous research (4) has demonstrated that weeds compete severely with container grown nursery crops and losses in terms of plant size can be devastating. Cultivation in the container nursery is impossible and manual weeding on a large scale is becoming prohibitively expensive.

Numerous reports have been published comparing the effects of preemergence herbicides for controlling weeds in container grown nursery stock (1, 2, 3). Many of the herbicides commercially available for use on container grown nursery crops will control annual grass weeds, but are likely to provide only limited control of broadleaf weeds. In a previously reported study (5), it was noted that oxyfluorfen resulted in excellent broadleaf weed control, but gave only limited annual grass control when used at a rate of 2.0 lb ai/A. Since this is quite contrary to the results normally expected from preemergent herbicides, an experiment was designed to further evaluate this compound, used alone at several rates and in combination with several well documented preemergent herbicides noted for their annual grass control.

MATERIALS AND METHODS

This study was conducted during the summer of 1979 at the Dept. of Horticulture nursery at The Ohio State University, Columbus, to evaluate the response of container grown nursery crops to granular oxyfluorfen [2-chloro-1-(3 ethoxy-4-nitrophenoxy)-4-(trifluoromethyl) benzene] (trade name Goal) at rates of 1.0, 2.0, 4.0, and 8.0 lb ai/A. These rates are equivalent to ½, 1, 2, and 4X the normal application. In addition, oxyfluorfen at its recommended rate of 2 lb ai/A was combined with four other herbicides in granular formulations including: simazine [2-chloro-4, 6-bis(ethylamino)-s-triazine] (trade name Princep) at 1.0 lb ai/A, oxadiazon [2-tert-butyl-4- (2,4-dichloro-5-isopropoxyphenyl) -Δ^2-1, 3, 4-oxadiazolin-5-one] (trade name Ronstar) at 4.0 lb ai/A, oryzalin [3, 5-dinitro-N^4, N^4-dipropylsulfanilamide] (trade name Surflan) at 4.0 lb ai/A, and prodiamine [N^3, N^3-di-n-propyl-2, 4-dinitro-6-trifluoromethyl-m-phenylene=diamine] (trade name Rydex) at 3.0 lb ai/A. Each of the four herbicides used in combination with oxyfluorfen was used at the manufacturer's recommended label rate.

Uniform cuttings of red-osier dogwood *(Cornus sericea)*, cranberry cotoneaster *(Cotoneaster apiculata)*, European cranberry viburnum *(Viburnum opulus* 'Notcutt'), border forsythia *(Forsythia intermedia* 'Spectabilis'), English ivy *(Hedera helix)*, green luster holly *(Ilex crenata* 'Green Luster'), Japanese pachysandra *(Pachysandra terminalis)*, Wyatti firethorn *(Pyracantha coccinea 'Wyattii')*, and Browni yew *(Taxus* x *media 'Brownii')* were planted in 1-gallon plastic nursery containers on May 15, 1979. The medium used for all plants was composed of 3 parts of ground hardwood bark, 1 part sand, and 1 part pine bark on a volume basis.

Twenty-four hours prior to the application of the herbicide treatments, large crabgrass *(Digitaria sanguinalis)*, rough pigweed *(Amaranthus retroflexus)*, lambsquarter *(Chenopodium album)*, and common ragweed *(Ambrosia artemisiifolia)* seed were sown in the containers to insure a uniform weed population.

All of the herbicides with the exception of one of the oxyfluorfen treatments at 2.0 lb ai/A were granular formulations, and were applied with a hand shaker over a predetermined area. The oxyfluorfen-2E was applied with a CO_2 constant rate sprayer calibrated to deliver a volume equivalent to 36 gallons per acre. Immediately following the herbicide applications on June 6, 1979, all treatments were irrigated with 1 inch of water in order to activate the

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TABLE 1.—Preemergent Control of Large Crabgrass, Rough Pigweed, Giant Ragweed, and Lambsquarter with Oxyfluorfen Applied Singly and in Combination on Container Grown Nursery Stock.

Treatment and Formulation	Rate	Percent Weed Control							
		Large Crabgrass		Rough Pigweed		Ragweed		Lambsquarter	
	lb ai/A	35*	60	35	60	35	60	35	60
Oxyfluorfen-2G	1.0	24.5	27.7	47.3	66.6	29.4	56.2	71.0	98.0
Oxyfluorfen-2G	2.0	44.8	45.3	75.7	88.7	57.6	80.2	82.2	97.4
Oxyfluorfen-2G	4.0	81.2	58.0	98.3	96.0	94.1	95.8	98.9	99.4
Oxyfluorfen-2G	8.0	93.7	83.9	97.6	97.8	97.3	99.1	96.8	99.8
Oxyfluorfen-2E	2.0	95.8	78.1	100.0	99.4	99.3	99.2	100.0	98.8
Oxyfluorfen-2G + Simazine-4G	2.0 + 1.0	68.6	54.4	86.6	92.6	89.8	94.1	96.7	99.8
Oxyfluorfen-2G + Oxadiazon-4G	2.0 + 4.0	91.9	86.0	100.0	99.6	91.7	90.9	100.0	100.0
Oxyfluorfen-2G + Oryzalin-5G	2.0 + 4.0	99.6	98.9	99.4	100.0	92.9	89.8	100.0	100.0
Oxyfluorfen-2G + Prodiamine-4G	2.0 + 3.0	95.4	85.4	98.7	100.0	70.0	71.1	99.1	100.0
Check-Unweeded		12.6	29.2	12.4	33.4	16.3	23.1	23.7	16.1
Check-Handweeded		93.4	93.9	94.0	96.7	90.8	92.6	96.2	99.8

*Days after herbicide application.

herbicides. During the course of this investigation, all plants received a standard fertilization and maintenance program.

Weed control and phytotoxicity evaluations were conducted 35 and 60 days after the herbicide applications. Crop phytotoxicity was evaluated using a 1 to 10 visual rating scale, where 1.0 = no injury and 10.0 = complete kill; weed control was evaluated using a 0 to 100 scale in comparison to the control plots. The study was designed and analyzed as a completely randomized block with four replications (three plants per replicate) of each treatment.

RESULTS

As expected, oxyfluorfen exhibited poor control of all four weed species at the ½ and 1X rates of 1.0 and 2.0 lb ai/A 35 days after application. However, at the 4.0 and 8.0 lb ai/A rates (2 and 4X the recommended rate), oxyfluorfen gave excellent control of all weed species (Table 1). While the manufacturer recommends the 2.0 lb ai/A rate of oxyfluorfen-2G, results in this study indicated that the 4.0 lb ai/A rate of the granular material gave superior broadleaf and grass weed control with no increased phytotoxicity (Table 1).

At both evaluation periods the application of oxyfluorfen in the 2E formulation at the 2.0 lb ai/A rate resulted in superior large crabgrass control (96 and 78%, respectively) when compared to the same rate applied in a granular formulation (45 and 45%, respectively). In addition, control of the three broadleaf weed species, rough pigweed, lambsquarter, and ragweed, was much improved with the 2E formulation when compared to the 2G application at the 2.0 lb ai/A rate (Table 1).

Both broadleaf and grass weed control performances of oxyfluorfen at the 2.0 lb ai/A rate were greatly enhanced when it was combined with simazine at 1.0 lb ai/A, oxadiazon at 4.0 lb ai/A, oryzalin at 4.0 lb ai/A, or prodiamine at 3.0 lb ai/A when compared to the oxyfluorfen 2G used singly at the 2.0 lb ai/A rate (Table 1).

At the recommended rate of 2.0 lb ai/A, the single application of oxyfluorfen-2G was safe on all nine ornamental crops, except the Wyatti firethorn when evaluated 35 days after application. As the rate of the granular oxyfluorfen increased to 8.0 lb ai/A, significant injury was apparent on the red-osier dogwood, cranberry cotoneaster, border forsythia, and Wyatti firethorn when evaluated 35 days after application. Sixty days after treatment, this injury was less apparent on all species except the cranberry cotoneaster (Table 2).

When evaluating the phytotoxicity, it became apparent that the 2E application at 2.0 lb ai/A resulted in significantly more injury than the comparable rate of the granular material, particularly when evaluated 35 days after application. Sixty days after application, phytotoxicity from the 2E application was less evident (Table 2).

In summary, oxyfluorfen at the recommended rate of 2 lb ai/A will not adequately control weed growth in container nursery crops to warrant any further evaluation. However, the combination of oxyfluorfen at the 2.0 lb ai/A rate with either 1.0 lb ai/A of simazine, 4.0 lb ai/A of oxadiazon, 4.0 lb ai/A of oryzalin, or 3.0 lb ai/A of prodiamine provided satisfactory annual grass and broadleaf weed control without increased crop phytotoxicity. In addition, the 4.0 lb ai/A rate of oxyfluorfen-2G warrants further evaluation, since it resulted in improved weed control without significantly increased phytotoxicity when compared to the 2.0 lb ai/A rate of granular oxyfluorfen. These treatments should be

TABLE 2.—Visual Evaluation of Herbicidal Phytotoxicity Following Application of Oxyfluorfen Singly and in Combination to Nine Species of Container Grown Nursery Crops.

Treatment and Formulation	Rate lb ai/A	Red-Osier Dogwood 35	Red-Osier Dogwood 60	Cranberry Cotoneaster 35	Cranberry Cotoneaster 60	European Cranberry Viburnum 35	European Cranberry Viburnum 60	Border Forsythia 35	Border Forsythia 60
Oxyfluorfen-2G	1.0	1.0*	1.0	2.8	1.5	2.8	3.0	2.8	1.0
Oxyfluorfen-2G	2.0	2.0	1.0	3.5	1.8	2.0	3.5	2.2	1.8
Oxyfluorfen-2G	4.0	1.0	1.0	3.2	1.2	3.5	3.8	2.2	1.0
Oxyfluorfen-2G	8.0	4.2	1.8	6.0	3.2	1.8	2.5	4.8	1.0
Oxyfluorfen-2E	2.0	6.8	2.2	7.0	4.5	1.5	2.0	4.2	1.0
Oxyfluorfen-2G + Simazine-4G	2.0 + 1.0	1.0	1.0	3.0	1.0	1.5	2.2	1.0	1.0
Oxyfluorfen-2G + Oxadiazon-4G	2.0 + 4.0	1.2	1.0	1.0	1.2	3.2	3.8	1.2	1.0
Oxyfluorfen-2G + Oryzalin-5G	2.0 + 4.0	2.8	1.0	1.0	1.0	2.0	3.8	1.8	1.0
Oxyfluorfen-2G + Prodiamine-4G	2.0 + 3.0	1.5	1.0	1.8	1.0	1.2	2.2	1.8	1.0
Check-Unweeded		1.0	1.0	3.2	2.5	1.0	1.5	4.0	1.0
Check-Handweeded		2.0	1.0	1.0	1.0	1.5	3.5	3.2	1.0
$LSD_{0.05}$		1.1	N.S.	1.3	0.7	N.S.	N.S.	1.3	N.S.

Treatment and Formulation	Rate lb ai/A	English Ivy 35	English Ivy 60	Green Luster Holly 35	Green Luster Holly 60	Japanese Pachysandra 35	Japanese Pachysandra 60	Wyatti Firethorn 35	Wyatti Firethorn 60	Browni Yew 35	Browni Yew 60
Oxyfluorfen-2G	1.0	1.5	1.0	2.0	2.0	1.2	1.0	4.8	3.2	1.0	1.0
Oxyfluorfen-2G	2.0	1.8	1.0	1.2	1.0	2.0	1.2	5.0	2.2	1.5	2.2
Oxyfluorfen-2G	4.0	2.0	1.8	3.2	1.8	3.2	1.8	3.5	1.2	1.2	1.5
Oxyfluorfen-2G	8.0	1.8	1.2	1.2	1.0	2.5	1.0	4.0	1.2	2.0	1.5
Oxyfluorfen-2E	2.0	5.0	1.0	5.2	1.0	6.5	5.0	7.2	3.0	2.2	1.8
Oxyfluorfen-2G + Simazine-4G	2.0 + 1.0	1.8	1.0	1.2	1.0	2.5	1.8	2.8	1.0	1.8	2.0
Oxyfluorfen-2G + Oxadiazon-4G	2.0 + 4.0	1.0	1.0	3.5	1.0	3.5	1.0	5.0	1.0	2.2	3.2
Oxyfluorfen-2G + Oryzalin-5G	2.0 + 4.0	1.2	1.0	2.0	1.0	1.0	1.0	4.0	2.0	1.8	1.8
Oxyfluorfen-2G + Prodiamine-4G	2.0 + 3.0	1.0	1.0	1.5	1.0	2.5	1.0	3.5	2.5	4.0	1.8
Check-Unweeded		1.0	1.5	2.0	2.0	1.0	1.0	4.5	3.0	1.2	2.2
Check-Handweeded		1.0	1.0	2.8	1.0	2.0	1.0	2.2	1.0	1.0	1.0
$LSD_{0.05}$		0.8	N.S.	1.4	N.S.	1.2	0.7	N.S.	N.S.	0.8	N.S.

*Visual rating scale: 1.0 = no injury; 10.0 = complete kill.

further evaluated to determine the full extent of their usefulness in controlling weed growth in container grown nursery stock.

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Tolerance of Greenspire Littleleaf Linden to Herbicides

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ABSTRACT

The tolerance of *Tilia cordata* 'Greenspire' to pre-emergence and post-emergence herbicides was compared. Simazine, paraquat, and glyphosate were too injurious for commercial use, while 2,4-D and cacodylic acid were not injurious and could be recommended for post-emergence weed control.

INTRODUCTION

Several commercial nurserymen have experienced various degrees of injury when using standard herbicides in planting of linden trees. Little information exists in the literature relative to the tolerance of linden to herbicides. Since producers were asking for herbicide recommendations, a 2-year study was initiated to evaluate pre-emergence and post-emergence herbicides on linden.

MATERIALS AND METHODS

Treatments and rates were: pre-emergence—simazine (Princep) at 3.0 and 15.0 lb active ingredient per acre (aia), post-emergence—glyphosate (Roundup) at 1.5 and 7.5 lb aia, paraquat (Paraquat) at 1.0 and 5.0 lb aia, and cacodylic acid (Phytar 560) at 2.5 and 12.5 lb aia. The first figure represents the 1X or recommended rate and the second is a 5X rate.

The study was initiated on June 21, 1977, with a repeat application June 23, 1978. All herbicides, applied with a 5 gal pressure sprayer, were directed at the lower 18 inches of the trunks of the trees to determine bark and sucker injury. The bark was brown in color, although young Littleleaf Lindens have a green undertone for several years. The study was conducted in a commercial nursery in Warren County, Ohio. The clay loam soil had a pH of 5.5 with drainage generally fair to poor. The plants were fertilized and were routinely treated for insect and disease control throughout the study. All the plants were *Tilia cordata 'Greenspire'* purchased as 5-6-foot branched whips in the spring of 1976 and grown for 1 year prior to treatment. There were four single tree replications per treatment.

Evaluations were conducted periodically during the growing seasons of 1977 and 1978, with a final observation on June 2, 1979, to determine survival and growth 2 years from treatment.

RESULTS AND DISCUSSION

Since the objective of this study was to evaluate phytotoxicity to the linden trees from various herbicides, no efficacy data are reported. Injury was evaluated by observing the tree canopy, bark of the trunk, and movement of herbicide from the suckers to the upper foliage.

Following 2 years of treatment and evaluation, the general tree condition as shown in Table 1 indicates varying states of tolerance.

Princep was absorbed through the root system, began to show injury symptoms at both rates in the foliage at the end of the first growing season, and became more damaging throughout the second growing season. The injury was expressed as mottled foliage, defoliation, and stem dieback in the high treatment rate and death of most trees.

Paraquat at the 5X rate injured linden by the middle of the first season, with the foliage becoming chlorotic between the veins of some trees. By September of the first season, the foliage had abscissed and dieback of some branches had developed in the 5X

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TABLE 1.—The Effects of Herbicides on the General Condition of Tilia cordata 'Greenspire'.

Treatment	Rate	Tree Condition*	Comments
Princep	1X	2.3	Foliage mottled, stem dieback
	5X	1.3	Most trees dead by end of second year
Lithate	1X	3.8	Very good condition
	5X	3.8	Very good condition
Paraquat	1X	3.5	Some leaf size reduction and yellow leaf color
	5X	1.3	Nearly all trees died
Phytar 560	1X	4.0	Excellent condition
	5X	4.0	Excellent condition
Roundup	1X	3.5	Slight leaf distortion
	5X	2.8	Severe leaf brittleness and cupping on trees with suckers only
Check		4.0	Excellent condition

*Visual scale following 2 years of treatments. 4.0 = excellent condition—leaf size and color normal; 3.0 = average to good condition, only slight to no dieback, leaf size or color abnormalities; 2.0 = poor or weakened condition—leaf size reduced, color yellow, some twig dieback; 1.0 = trees dead.

TABLE 2.—The Effects of Herbicides on Trunk Bark Splitting of *Tilia cordata* 'Greenspire'.

Treatment	Rate	Bark Splitting*	Comments
Princep	1X	3.0	No bark injury
	5X	3.0	No bark injury
Lithate	1X	3.0	No bark injury
	5X	2.8	Small split on one tree only
Paraquat	1X	2.5	Numerous small splits
	5X	1.0	Severe splitting completely around trunk
Phytar 560	1X	3.0	No bark splitting
	5X	3.0	No bark splitting
Roundup	1X	3.0	No bark splitting
	5X	2.5	One tree with a 3-inch split
Check		3.0	No bark splitting

*Visual scale following 2 years of treatment. 3.0 = no trunk splitting; 2.0 = slight trunk splitting with splits from 0 to 3 inches; 1.0 = severe trunk splitting with splits more than 3 inches.

treatments. Nearly all trees in the high Paraquat rate had died by the final evaluation.

In the Roundup treatment there was very little injury the first season. However, leaf distortion and brittleness became obvious the second season. The higher the treatment rate, the greater the degree of injury of some trees.

The Lithate and Phytar 560 treatments did not result in injury symptoms that would be harmful to commercial production.

Since bark injury is common from herbicides applied to trees that have some green tissue in their trunk, an evaluation was conducted of each tree trunk. As shown in Table 2, the only severe injury to the trunks was from Paraquat treatment, particularly the 5X rate. Symptoms were noted the first growing season as a blistering effect with an orange to red coloration.

By autumn of 1977 the trunk became whitish in color with small holes and vertical hairline cracks ½ to 2 inches in length. During the second season the trunk tissue developed larger cracks and peeling, with some trunk swelling.

Only an occasional split or crack was observed on trees in other treatments and most likely these were not related to herbicide treatment. Lindens have a tendency to split when under stress from lack of adequate nutrition (2) or other causes.

All four post-emergence herbicides killed the suckers present on the trunk at the time of treatment. Only the Roundup treatment proved damaging to the tree canopy, however, as the herbicide was translocated from the suckers to the upper foliage. The symptoms were not observed until the second growing season. The injury symptoms would not be acceptable to a commercial grower. There was no foliar injury noted when suckers were not present at the time of spraying. Injury to Littleleaf Linden from Roundup with suckers present has been previously reported (1).

TABLE 3.—The Effects of Herbicide Contact with Suckers on *Tilia cordata* 'Greenspire'.

Treatment	Rate	Suckers Killed*	Herbicide Translocated*
Princep	1X	No	No
	5X	No	No
Lithate	1X	Yes	No
	5X	Yes	No
Paraquat	1X	Yes	No
	5X	Yes	No
Phytar	1X	Yes	No
	5X	Yes	No
Roundup	1X	Yes	Yes
	5X	Yes	Yes
Check		No	No

*Evaluation based on observations from a minimum of two trees/treatment for 2 years, with suckers varying in length from 3 to 24 inches.

SUMMARY

Greenspire Littleleaf Linden is susceptible to injury from Princep, Paraquat, and Roundup. Lithate and Phytar 560 did not injure the trees at recommended and 5X rates and could be used to control weeds in linden. Lithate is selective for broadleaf weeds only, while Phytar 560 is no longer formulated. However, cacodylic acid, the active ingredient in Phytar 560, is available under other trade names.

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Defoliation of 14 Species and Cultivars of Linden (Tilia Species) by the Feeding of Adult Japanese Beetles (*Popillia japonica* Newman) During the Summer of 1979

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ABSTRACT

A number of lindens were not injured as severely by the feeding of Japanese beetle adults as were Sorbus and Corylus. Upright American linden, Chancellor, Rancho, and XP110 littleleaf linden, Mongolian linden, and silver linden were not favored hosts and suffered only moderate damage even when subjected to large numbers of beetles. Greenspire littleleaf linden, Crimean linden, and large leafed lindens should be avoided in areas subject to heavy infestations of Japanese beetles.

INTRODUCTION

The Japanese beetle is becoming a serious pest in portions of Ohio (3). Japanese beetle populations in the Wooster area have been high for the last several years. These pests are voracious feeders and can seriously damage or defoliate some trees.

Lindens are generally considered to be a favored food source for the Japanese beetle adult (1, 2, 3, 4). Lindens may be excluded from city plantings where the Japanese beetle has been a problem in recent years. Municipalities in general are unable to spray street trees in order to control a pest such as Japanese beetle. Cost is certainly a factor in this decision of municipalities, but the liability associated with spraying operations is frequently the major concern.

A much more satisfactory approach for cities would be to plant trees which are not a favored host of this particular insect. Due to the wide range of genetic characteristics in the genus *Tilia,* and previous observations, it was thought that one or more species may not be a favored host. The shade tree evaluation plots located in Wooster, with more than 140 species and cultivars of trees, offer a unique opportunity to test this concept.

MATERIALS AND METHODS

Between the spring of 1967 and the spring of 1969, 14 species and cultivars of Linden *(Tilia)* were planted at the shade tree evaluation plots at the Ohio Agricultural Research and Development Center in Wooster. Eight trees per species and cultivars were planted in a random pattern 25 feet on centers. Over the years, some of the trees have died from transplant shock, mechanical injury, and disease problems. A list of the species and cultivars and the number of surviving trees are given in Table 1.

Maintenance of the trees has been minimal and has been similar to care afforded trees in a municipality. Fertilizer has been applied once and trees were sprayed in recent years to control Japanese beetle. In 1979, it was decided to evaluate the trees and to determine if there was any difference between species or cultivars in the severity of feeding due to the Japanese beetle. Trees were evaluated several times during July and August 1979. The data presented are based on an evaluation conducted on August 16, 1979. At this time, the majority of feeding by the Japanese beetle adults was complete. The numbers of beetles present since that time have been relatively small and damage since the evaluation on August 16 has been minimal.

No attempt was made to control feeding of the Japanese beetle adults during this test. It was believed that a homeowner would probably wish to spray when damage exceeded 15% of the foliage. Damage became noticeable when more than 15% of the foliage was destroyed.

TABLE 1.—Numbers of Plants of 14 Species and Cultivars Growing in the Shade Tree Evaluation Plot at OARDC.

Species	Cultivar	Number of Plants
Americana	fastigiata	6
cordata	sp.	6
	Chancellor	6
	Greenspire	6
	Rancho	8
	XP110	8
euchlora	sp.	7
	Redmond	8
Europeae	sp.	4
	Pallida	8
mongolica	sp.	3
platyphyllos	fastigiata	5
	Orebro	8
tomentosa	sp.	8

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TABLE 2.—Percent of Defoliation of 14 Species and Cultivars of Linden by Japanese Beetle Adults in the Summer of 1979.

Species	Cultivar	Percent of Defoliation	Number of Plants	Std. Dev.
Americana	fastigiata	31	6	14
cordata	sp.	65	6	30
	Chancellor	33	6	26
	Greenspire	86	6	12
	Rancho	35.0	8	16
	XP110	39	8	10
euchlora	sp.	77	7	4
	Redmond	76	8	14
Europeae	sp.	80	4	14
	Pallida	43	8	15
mongolica	sp.	23	3	15
platyphyllos	fastigiata	70	5	14
	Orebro	71	8	22
tomentosa	sp.	31.2	8	13

RESULTS AND DISCUSSION

Two linden species, *T. euchlora* and *T. platyphyllos,* were severely injured in this study. *Tilia cordata* and *T. europeae* are intermediate, with some cultivars highly prone to injury and some showing reduced feeding. The American linden *(Tilia americana),* Mongolian linden *(Tilia mongolica),* and the silver linden *(Tilia tomentosa)* were the least severely injured species (Table 2).

The beetle populations in Wooster in 1979 were quite high. On the most favored host, as many as 20 beetles per leaf were observed feeding at one time. Favored hosts, such as Greenspire linden, Redmond linden, the Crimean linden, the European linden, and the fastigiate and Orebro largeleaf lindens, tend to attract larger numbers of beetles than would otherwise be present. The less severely injured types, such as the upright American linden, Chancellor, Rancho, XP110 littleleaf linden, Mongolian linden, and the silver linden, would probably not require spraying under normal conditions.

The variation in favoritism within the littleleaf linden species is remarkable. City arborists and homeowners alike can take advantage of the fact that Chancellor, Rancho and XP110 littleleaf lindens are not favored host plants. Under relatively light infestations, little or no spraying would be required. Even if 30 to 40% of the foliage was damaged, the photosynthetic capability of the plant would likely be only slightly affected. These plants will probably not be adversely affected as far as growth rate is concerned, although the damage would be quite noticeable.

The feeding of the beetles on plants other than linden was also evaluated. A comparison of linden and a number of other genera (Table 3) gives an idea of how lindens compare in general with other genera of plants. Filbert (Corylus) and Mountain Ash (Sorbus) were the most severely damaged by the Japanese beetle. More than 80% of the foliage of these two plants was destroyed. In contrast, linden and elm (Ulmus) showed about 50% defoliation. A number of other commonly grown genera of trees showed little or no injury.

Additional time will be required to properly evaluate the impact of the Japanese beetle on lindens. The depression of growth rate, if it exists, will be documented as will the feeding habits of the insect for the next several years. As additional information becomes available, it will be possible to take advantage of the well known tolerance of the lindens to city conditions without having to be overly concerned about the feeding of the Japanese beetle.

TABLE 3.—Defoliation of 12 Genera of Shade Trees by Japanese Beetles in the Summer of 1979.

Genera	Percent of Defoliation
Acer	3
Corylus	88
Crataegus	20
Fraxinus	0
Ginkgo	2
Gleditsia	0
Malus	16
Platanus	1
Quercus	23
Sorbus	82
Tilia	54
Ulmus	52

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Evaluation of Fungicides for Control of Some Ornamental Plant Diseases

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ABSTRACT

Fungicide evaluation trials were conducted on a number of trees, shrubs, and herbaceous plants. Leaf blight and powdery mildew on zinnia were both controlled with copper hydroxide (Kocide 101), but the product was phytotoxic. Black spot on rose was controlled well with a fungicide consisting of 10% carbendazim plus 64% mancozeb (DPX 164-2). Scab on firethorn was completely prevented with copper hydroxide. Powdery mildew on Mollis azalea was eliminated with triadimefon. Mancozeb (Manzate 200) was found to be safe for use on hollyhock, aster, snapdragon, and chrysanthemum.

INTRODUCTION

Although there are many ways to control or manage plant diseases, fungicides remain as one of the most important tools (5). A research program has been underway at The Ohio State University for some time to provide data necessary to get increased labeling of already available products as well as new experimental fungicides (6, 7). This additional labeling is needed to enable ornamental plant horticulturists and nurserymen to use fungicides against plant diseases legally.

Because of the high value of ornamental crops, chemical companies must be convinced through data that their product is effective at controlling the disease as well as safe, not phytotoxic, to the crop. Ornamental crop uses are considered a "specialty" or "minor" market by most chemical companies because there are no large acreages as with corn, soybeans, etc. Fortunately, however, most companies will proceed with label expansion and development if sound information is made available to them.

Since there are so many different crops and diseases covered under the term "ornamentals", it is important that fungicides be developed that are general enough in their activity to be useful against a wide variety of pathogens and safe on most kinds of plants (1, 3). A fungicide that might be extremely effective against one disease on one crop is not as useful to the ornamentalist as one that is moderately effective, but that has potential for broad label development (5). This is why older fungicides, such as coppers or EBDC's, are prominent in this research program (6, 7). Several combination materials also were included in this year's projects.

The disease systems chosen for research comprise models that give a good indication of the general usefulness of the fungicides (2, 4). Zinnia, for instance, is not a particularly important ornamental. However, this plant has been used by many researchers as a convenient system to assess the safety of fungicides on herbaceous annuals as well as to evaluate the ability of a product to control two rather diverse pathogens at the same time on the same plant (4). There are several tests in which the disease did not naturally develop this past year. Still, results are reported concerning phytotoxicity, since this is of equal importance to efficacy as far as usefulness of the product is concerned (8).

METHODS AND RESULTS

Trial 1: Leaf blight (caused by *Alternaria zinniae*) and powdery mildew (caused by *Erysiphe cichoracearum*) on zinnia (*Zinnia-elegans*): Zinnia seed was planted in May 1978 into field rows that were overhead irrigated as needed. When plants were approximately 2 feet tall, they were sprayed on a bi-weekly schedule on July 17, 1978, July 31, 1978, August 15, 1978, and August 29, 1978. Four randomized replications of approximately 6 feet of row per replication were sprayed for each of the 18 treatments. Plants were sprayed to runoff with a 2-gallon CO_2-pressurized sprayer (25 psi). Disease severity ratings for powdery mildew and leaf blight and phytotoxicity ratings were taken on Sept. 18, 1978 (Table 1).

Both diseases were quite severe by season's end. Mildew was best controlled by those treatments containing benomyl (Benlate, DPX 115B, DPX 112-2) or carbendazim (DPX 164-12). Blight was best controlled by Kocide or by treatments containing maneb or mancozeb. It is not known why the Benlate plus Manzate 200 tank mixed treatment did so poorly on blight control. The copper fungicides were quite phytotoxic in this test and should not be used on zinnias. The other treatments that resulted in toxicity ratings averaging less than 1 were hardly noticeable.

Trial 2: Black spot (caused by *Diplocarpon rosae*) on rose (*Rosa dilecta* 'Peace' and 'Command Performance'): Bi-weekly sprays on both cultivars were initiated on June 19, 1978, and were

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TABLE 1.—Blight and Mildew Control on Zinnia.

Treatment and Rate/100 Gallons	Mildew Severity*	Blight Severity	Phytotoxicity
DPX 115 B 60 WP 3 lb + Exhalt 800 8 oz	0.0 a†	1.8 abcd	0.5 a
DPX 115 B 60 WP 1.5 lb + Exhalt 800 8 oz	0.0 a	2.4 abcd	0.0 a
DPX 164-2 74 WP 2 lb + Exhalt 800 8 oz	0.0 a	2.5 abcd	0.0 a
Benlate 50 WP 8 oz + Manzate 200 80 WP 1 lb + Exhalt 800 8 oz	0.0 a	3.3 d	0.0 a
DPX 164-2 74 WP 4 lb + Exhalt 800 8 oz	0.3 a	1.3 ab	0.0 a
DPX 112-2 80 WP 4 lb + Exhalt 800 8 oz	0.4 ab	2.0 abcd	0.0 a
DPX 112-2 80 WP 2 lb + Exhalt 800 8 oz	0.8 abc	1.5 abc	0.0 a
Daconil 4F 8 pt	1.2 abcd	1.6 abc	0.0 a
Kocide 101 77 WP 4 lb + Exhalt 800 8 oz	1.4 abcde	1.0 a	3.8 c
Daconil 4F 2 pt	1.8 bcde	2.3 abcd	0.0 a
Triforine 18.2 EC 48 oz	2.0 cde	3.0 cd	0.3 a
Manzate 200 80 WP 6 lb + Exhalt 800 8 oz	2.3 de	1.3 ab	0.5 a
Kocide 101 77 WP 1 lb + Exhalt 800 8 oz	2.5 de	1.5 abc	3.3 c
Manzate 200 80 WP 1.5 lb + Exhalt 800 8 oz	2.8 ef	1.0 a	0.3 a
Triforine 18.2 EC 12 oz	4.0 fg	2.8 bcd	0.8 a
Citcop 4E 2 qt	4.3 g	2.5 abcd	2.0 b
Citcop 4E 4 qt	4.4 g	3.2 d	3.6 c
Check	5.0 g	5.0 e	0.0

*Mildew and blight severity: 0 = no disease, 5 = 100% of foliage infected; phytotoxicity: 0 = no damage, 5 = 100% of foliage exhibiting necrotic flecking.

†The small letters indicate Duncan's multiple range groupings of treatments which do not differ significantly at the 0.05 level.

TABLE 2.—Black Spot Control on Two Cultivars of Hybrid Tea Roses.

	Disease Severity*		
Treatment and Rate/100 Gallons	August 7 (Peace)	August 7 (Com. Per.)	August 29 (Peace)
CGA 64251 0.846 EC 1 pt	0.0 a†		1.4 bc
CGA 64251 0.846 EC 1 qt	0.1 a		0.8 ab
Benlate 50 WP 8 oz + Exhalt 800 8 oz	0.3 a	0.2 a	1.4 bc
DPX 164-2 74 WP 4 lb + Exhalt 800 8 oz	0.5 ab	0.0 a	0.5 a
DPX 164-2 74 WP 2 lb + Exhalt 800 8 oz	0.8 b	0.5 a	1.9 c
Citcop 4E 2 qt	4.0 c		4.6 d
Citcop 4E 4 qt	4.0 c		4.6 d
Bayleton 50 WP 2 oz + Exhalt 800 8 oz		2.0 b	
Bayleton 50 WP 4 oz + Exhalt 800 8 oz		3.2 bc	
Check	4.5 d	4.0 c	4.8 d

*Disease severity: 0 = no disease, 5 = 100% of foliage with at least one lesion or defoliated.

†The small letters indicate Duncan's multiple range groupings of treatments which do not differ significantly at the 0.05 level. Each observation analyzed separately.

repeated on June 30, 1978, July 14, 1978, July 27, 1978, and August 10, 1978. Two-to-three year-old plants were treated in non-irrigated field plantings on 4-foot centers in the row. For the 'Command Performance' roses, three randomized replications of three plants each for six treatments were sprayed and for the 'Peace' roses four replications of six plants were sprayed to runoff with a 2-gallon CO_2-pressurized sprayer (25 psi). The 'Peace' roses were rated for disease severity on August 7, 1978, and August 26, 1978, and the 'Command Performance' roses were rated on August 7, 1978 (Table 2).

Citcop and Bayleton did not adequately control the disease at these rates and spray intervals. The August 29 observation was made 19 days after the last spray and indicates that all effective chemicals were about equal in residual protection, with DPX 164-2 at 4 lb being the best. However, the DPX 164-2 treatment resulted in an unacceptable residue at either rate. On August 29, there was a suggestion of leaf thickening and stunting of the 'Peace' roses treated with CGA 64251 at 1 quart/100 gallons. No other phytotoxicity was noted.

Trial 3: Scab (caused by *Fusicladium pyracanthe*) on firethorn (*Pyracantha coccinea* 'Lalandei'): Plants were grown in 2-gallon containers under standard nursery conditions with overhead irrigation. Treatments were applied on a bi-weekly schedule on June 7, 1978, June 21, 1978, July 6, 1978, July 19, 1978, August 2, 1978, and August 16, 1978. A randomized complete block design was used with four replications of approximately 45 plants per replication for each of seven treatments. Plants were sprayed to runoff with a 2-gallon CO_2-pressurized sprayer (25 psi). Disease severity and phytotoxicity were rated on August 24, 1978 (Table 3).

Although disease was severe in the check plants, excellent control of scab was obtained with both copper fungicides. The Kocide treated plants had a heavy residue apparent at all times with both rates. This should not affect salability, however. Strepto-

TABLE 3.—Fungicides for Control of Scab on Firethorn.

Treatment and Rate/100 Gallons	Disease Severity*	Phytotoxicity†
Kocide 101 77 WP 4 lb + Exhalt 800 8 oz	0.0 a‡	0
Kocide 101 77 WP 1 lb + Exhalt 800 8 oz	0.0 a	0
Citcop 4E 4 qt	0.1 a	0
Citcop 4E 2 qt	0.2 a	0
Agristrep 21.2 WP 4 lb + Exhalt 800 8 oz	2.6 b	1.7
Agristrep 21.2 WP 1 lb + Exhalt 800 8 oz	2.7 b	0.3
Check	3.6 c	0

*Disease severity: 0 = no disease, 5 = 100% of leaves with at least one scab.
†Phytotoxicity: 0 = no phytotoxicity, 5 = all young foliage with chlorotic leaf tips (plants rated 4 or above were unsalable).
‡The small letters indicate Duncan's multiple range groupings of treatments which do not differ significantly at the 0.05 level.

TABLE 4.—Control of Powdery Mildew on Mollis Azalea.

Treatment and Rate/100 Gallons	Disease Severity*
Bayleton 25 WP 4 oz + Exhalt 800 8 oz	0.0 a†
Bayleton 25 WP 8 oz + Exhalt 800 8 oz	0.0 a
Triforine 18.2 EC 48 oz	0.1 a
Bayleton 50 WP 4 oz + Exhalt 800 8 oz	0.1 a
Triforine 18.2 EC 12 oz	0.2 a
Benlate 50 WP 8 oz + Exhalt 800 8 oz	0.2 a
Benlate 50 WP 16 oz + Exhalt 800 8 oz	0.3 ab‡
Bayleton 50 WP 2 oz + Exhalt 800 8 oz	0.3 ab
Bayleton 50 WP 4 oz + Exhalt 800 8 oz	0.6 b‡
Check	2.1 c

*Disease severity: 0 = no disease, 5 = 100% of upper leaves with at least one powdery mildew colony.
†The small letters indicate Duncan's multiple range groupings of treatments which do not differ significantly at the 0.05 level.
‡These treatments applied monthly.

TABLE 5.—Phytotoxicity Test on Aster, Hollyhock, Snapdragon, Chrysanthemum.*

Treatments†	Rate/100 Gal	Phytotoxicity			
		Hollyhock‡	Aster	Snapdragon	Chrysanthemum‡
Daconil 4F	2 pt	2.7	None	None	1.0
Daconil 4F	8 pt	3.0	None	None	1.3
Manzate 200 80 WP + Exhalt 800	1.5 lb + 8 oz	0.0	None	None	0.0
Manzate 200 80 WP + Exhalt 800	6 lb + 8 oz	2.3	None	None	3.3
H719 (4BI-1218) 3.3EC	120 oz	4.0	None	None	0.3
H719 (4BI-1218) 3.3EC	60 oz	3.9	None	None	2.7
H719 (4BI-1218) 3.3EC	30 oz	4.0	None	None	0.7
Plantvax 75 WP + Exhalt 800	1 lb + 8 oz	2.7	None	None	1.0
DPX 112-2 + Exhalt 800	2 lb + 8 oz	2.7	None	None	0.7
DPX 112-2 + Exhalt 800	4 lb + 8 oz	2.7	None	None	0.0
Check		0.0	None	None	0.0

*Cultivars were: Aster hybridus 'Bonnie Blue', Althaea rosea, Antirrhinum majus 'Floral Carpet', and Chrysanthemum hortorum 'Ruby Mound'.

†Applications were made on May 27, 1979, June 14, 1979, June 28, 1979, July 14, 1979, July 30, 1979, August 15, 1979, and Sept. 1, 1979. Final observation made on Sept. 15, 1979.

‡Hollyhock damage consisted of marginal leaf burn and chlorosis, rated on a 0 to 5 scale (5 = 100% of foliage affected). Chrysanthemum damage consisted of open flower burn, rated on a 0 to 5 scale (5 = 100% of opened flowers affected).

TABLE 6.—Phytotoxicity Test on Pachysandra.

Treatments*	Rate/100 Gallons	Phytotoxicity
Benlate 50 WP + Exhalt 800	8 oz + 8 oz	None
Benlate 50 WP + Exhalt 800	16 oz + 8 oz	None
Benlate 50 WP + Exhalt 800	64 oz + 8 oz	None
Benlate 50 WP + Manzate 200 80 WP + Exhalt 800	8 oz + 16 oz + 8 oz	None
Benlate 50 WP + Manzate 200 80 WP + Exhalt 800	32 oz + 64 oz + 8 oz	None
Daconil 4F	2 pt	None
Daconil 4F	8 pt	None
DPX 164-2 + Exhalt 800	2 lb + 8 oz	None
DPX 164-2 + Exhalt 800	4 lb + 8 oz	None
Check		

*Applications were made on August 3, 1979, August 16, 1979, August 30, 1979, and Sept. 15, 1979. Final observation was made on Sept. 30, 1979.

TABLE 7.—Phytotoxicity Test on Myrtle (Vinca Minor).

Treatments*	Rate/100 Gallons	Phytotoxicity
Benlate 50 WP + Exhalt 800	8 oz + 8 oz	None
Benlate 50 WP + Exhalt 800	16 oz + 8 oz	None
Benlate 50 WP + Exhalt 800	64 oz + 8 oz	None
Benlate 50 WP + Manzate 200 80 WP + Exhalt 800	8 oz + 16 oz + 8 oz	None
Benlate 50 WP + Manzate 200 80 WP + Exhalt 800	32 oz + 64 oz +8 oz	None
Daconil 4F	2 pt	None
Daconil 4F	8 pt	None
Manzate 200 + Exhalt 800	1.5 lb + 8 oz	None
Kocide 101 77 WP + Exhalt 800	1 lb + 8 oz	None
Kocide 101 77 WP + Exhalt 800	4 lb + 8 oz	None
Check		None

*Applications were made on July 16, 1979, July 20, 1979, Sept. 2, 1979, Sept. 16, 1979, Sept. 30, 1979, and Oct. 15, 1979. Final observation was made on Oct. 30, 1979.

mycin was not effective in controlling the disease. Furthermore, it was slightly phytotoxic, with 13 out of 180 treated plants being unsalable.

Trial 4: Powdery mildew (caused by (*Microsphaera alni*) on Mollis azalea (*Rhododendron* sp.): Field grown 'Mollis' azaleas (approximately 2 feet tall) were sprayed bi-weekly with seven fungicide treatments on August 16, 1978, August 31, 1978, and Sept. 15, 1978. Two treatments were sprayed on a monthly schedule August 16, 1978, and Sept. 15, 1978. Three randomized replications of approximately 16 plants were sprayed to runoff with a 2-gallon CO_2-pressurized sprayer (25 psi). Moderate disease incidence was present in the test plants just prior to initiation of the experiment. Disease ratings were based on infection of upper foliage that occurred after the trial was begun. Disease severity was rated on Sept. 25, 1978 (Table 4).

All treatments adequately controlled the disease. Bayleton 50 WP sprayed monthly may have performed better at higher rates. No phytotoxicity was noted.

Trials 5-10: Phytotoxicity evaluations of selected fungicides on aster (*Aster hybridus* 'Bonnie Blue'), hollyhock (*Althaea rosea*), snapdragon (*Antirrhinum majus* 'Floral Carpet') chrysanthemum (*Chrysanthemum hortorum* 'Ruby Mound'), pachysandra (*Pachysandra terminalis*), and myrtle (*Vinca minor*): For each of these experiments, three randomized blocks of 8 feet of bed or row were treated for each treatment listed. Plants were sprayed to runoff with a 2-gallon CO_2-pressurized sprayer (25 psi) according to application schedules noted in Tables 5, 6, and 7. Rates four times higher than necessary to control the disease were tested purposely to evaluate the potential for plant damage.

TABLE 8.—Experimental Fungicides Used in Reported Trials.

Product	Source	Common Chemical Name
Bayleton 25 and 50 WP	Mobay Chemical Corp. Kansas City, Mo.	triadimefon
CGA-64251 0.846 EC	Ciba-Geigy Agri. Div. Greensboro, N. C.	No common name
DPX 164-2 74 WP	E. I. duPont de Nemours & Co., Wilmington, Del.	10% carbendazim + 64% mancozeb
DPX 115B 60 WP	E. I. duPont de Nemours & Co., Wilmington, Del.	6% benomyl + 60% maneb
H 719 75 WP	Uniroyal, Inc. Bethany, Conn.	No common name

Some phytotoxicity was noted on some of the herbaceous plants tested (Table 5). The ground covers were not damaged by any treatment (Tables 6 and 7).

DISCUSSION

The products that contain combinations of carbendazim or benomyl plus captan or maneb hold promise for use in ornamental disease control (Table 8). They have wide activity and are generally safe on plant material (3, 8). Furthermore, they appear to be more effective than tank mixes of fungicides sold separately. Copper fungicides, the EBDC's, and Daconil also performed well in most of the test. There were cases, however, when these products damaged plants or failed to control the pathogen. Tests in other areas of the United States generally confirmed these findings (1, 4, 8). One must be careful in any attempts to generalize. Bayleton was an effective experimental fungicide for control of powdery mildews.

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